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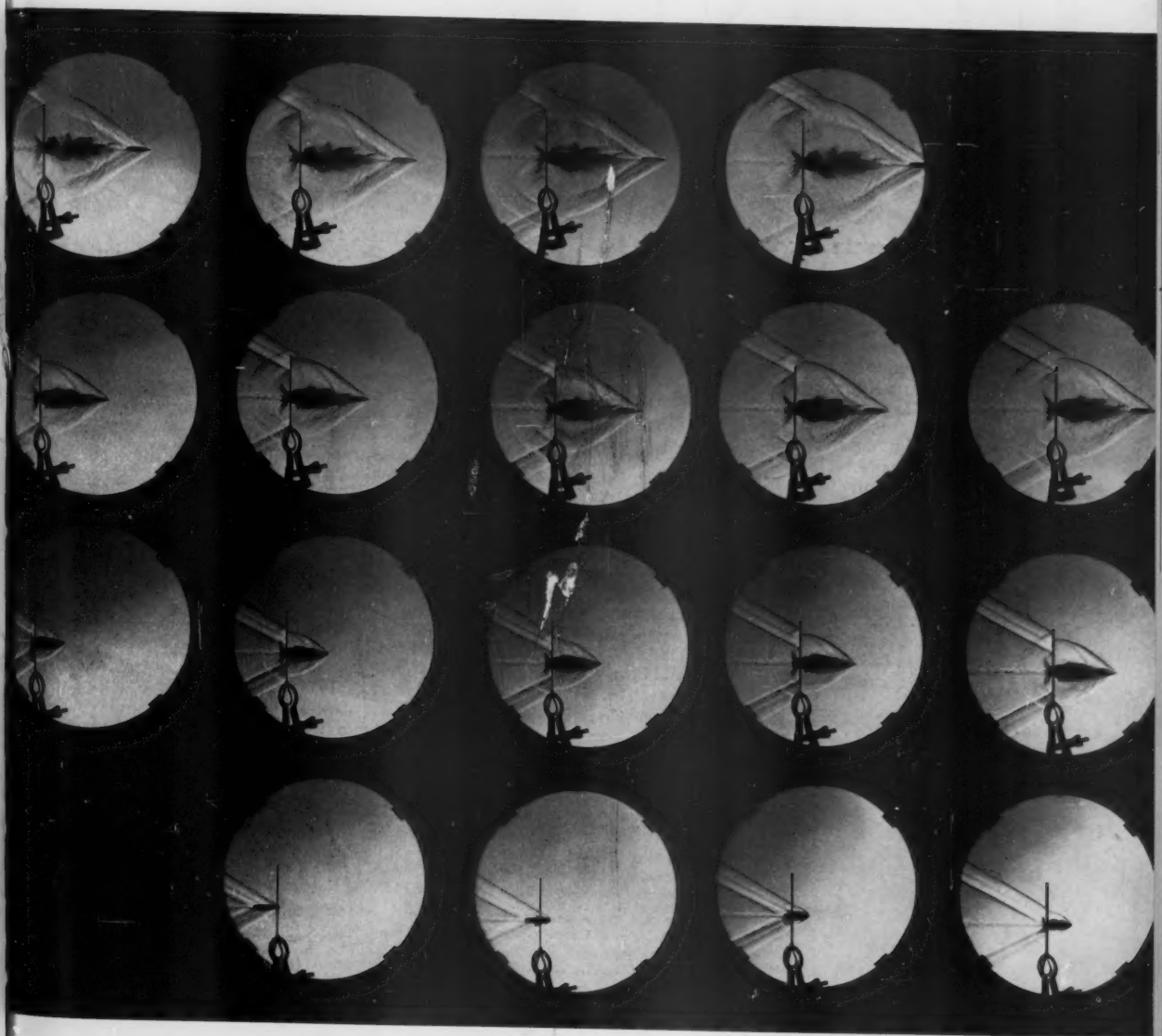

Instrument Issue

Thomas

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. . . for determining melting points by use of a thermistor in place of mercury-in-glass thermometers

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- **Can be used with any Thomas-Kofler Hot Stage**
- **Audible signal permits *uninterrupted* observation**
- **Single sensor for entire temperature range**
- **Faster response**
- **Simple graphic reader converts resistance values to temperature readings**
- **Bridge Alarm permits unattended heating and cooling of Stage**

3963-A7.

AUDIOHM THERMISTOR KOFLER HOT STAGE ASSEMBLY, Thomas. For determination of micro melting points and other fusion phenomena temperatures *without removing the eye from the microscope.*

Other advantages of the thermistor method are faster response, obtained by locating a smaller sensor closer to the field of observation than is possible with a thermometer, and the elimination of stage-calibrated thermometers.

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The assembly shown above consists of Thomas-Kofler Hot Stage—described on pp. 877 to 880, incl., of our catalog—with the following Audiohm Thermistor accessories in place of the usual thermometers:

Thermistor Hot Stage Attachment. A chromium plated, circular brass block, with 1 mm bead type thermistor. Fits directly on any Thomas-Kofler Hot Stage in place of detachable rim.

Audiohm Resistance Bridge. Range 0.2 to 2,500,000 ohms, 1000-cycle output; with phone jack for earphones, and octal socket in rear to take Bridge Alarm.

Earphones. For attachment to Resistance Bridge to detect null point of audible signal.

Thermistor Temperature Computor. A circular slide rule on 16-inch square plastic base plate. For converting resistance values directly to temperature readings in the range 20° to 350° C.

6887-C2. Audiohm Thermistor Hot Stage Assembly, Thomas-Kofler, complete as illustrated, consisting of Hot Stage with transformer, Thermistor Attachment for the stage, Audiohm Resistance Bridge, Earphones, and Thermistor Temperature Computer; without Microscope or Bridge Alarm. For 115 volts, 50 or 60 cyc. a.c. **422.95**

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Perkin-Elmer *Corporation*
NORWALK, CONNECTICUT

23 October 1959, Volume 130, Number 3382

SCIENCE

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Bullet penetrating a pane of glass. The framing sequence runs from bottom to top, left to right. This high-speed schlieren photograph was taken with a Cranz-Schardin camera by Pierre Naslin, Laboratoire Central de l'Armement, Paris, France. See page 1051.

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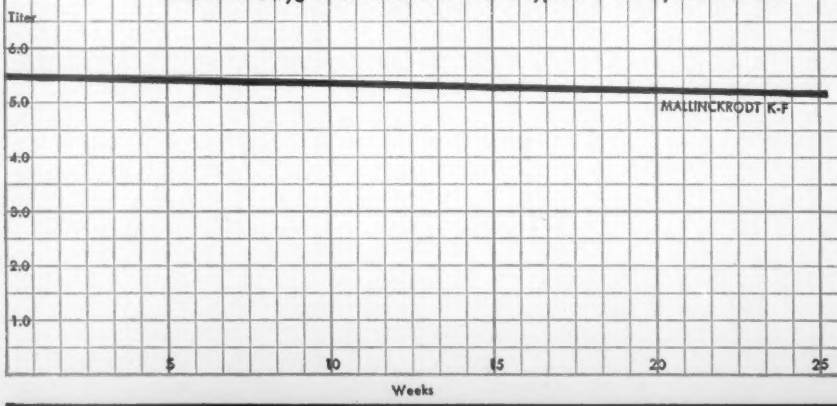

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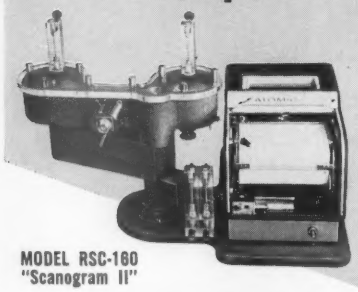

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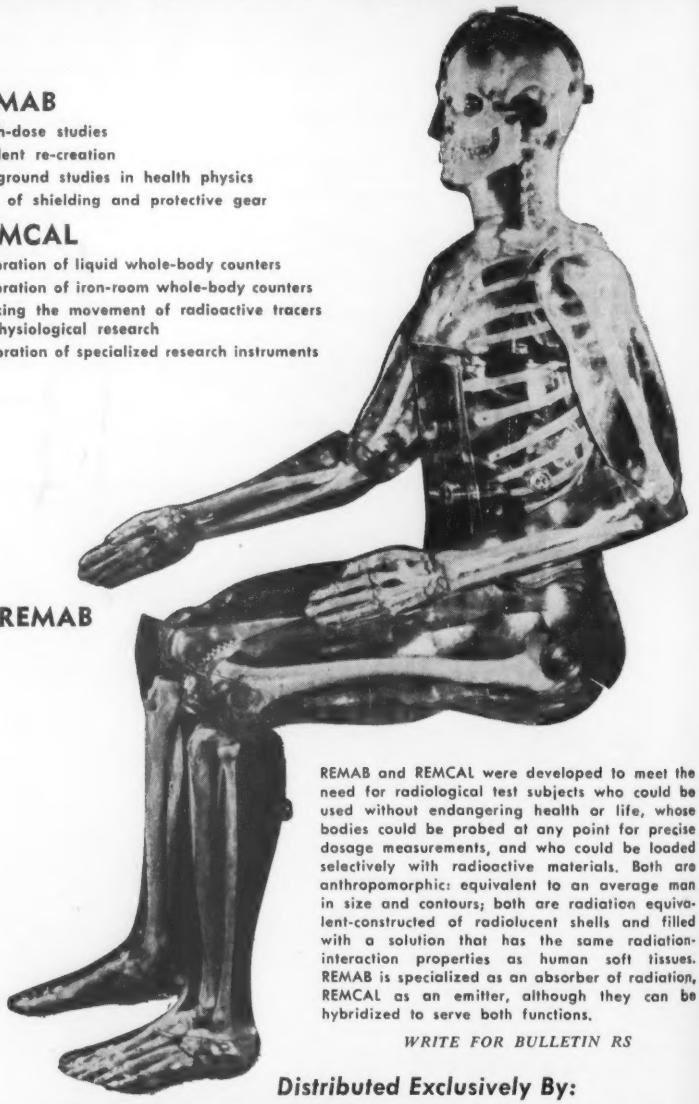

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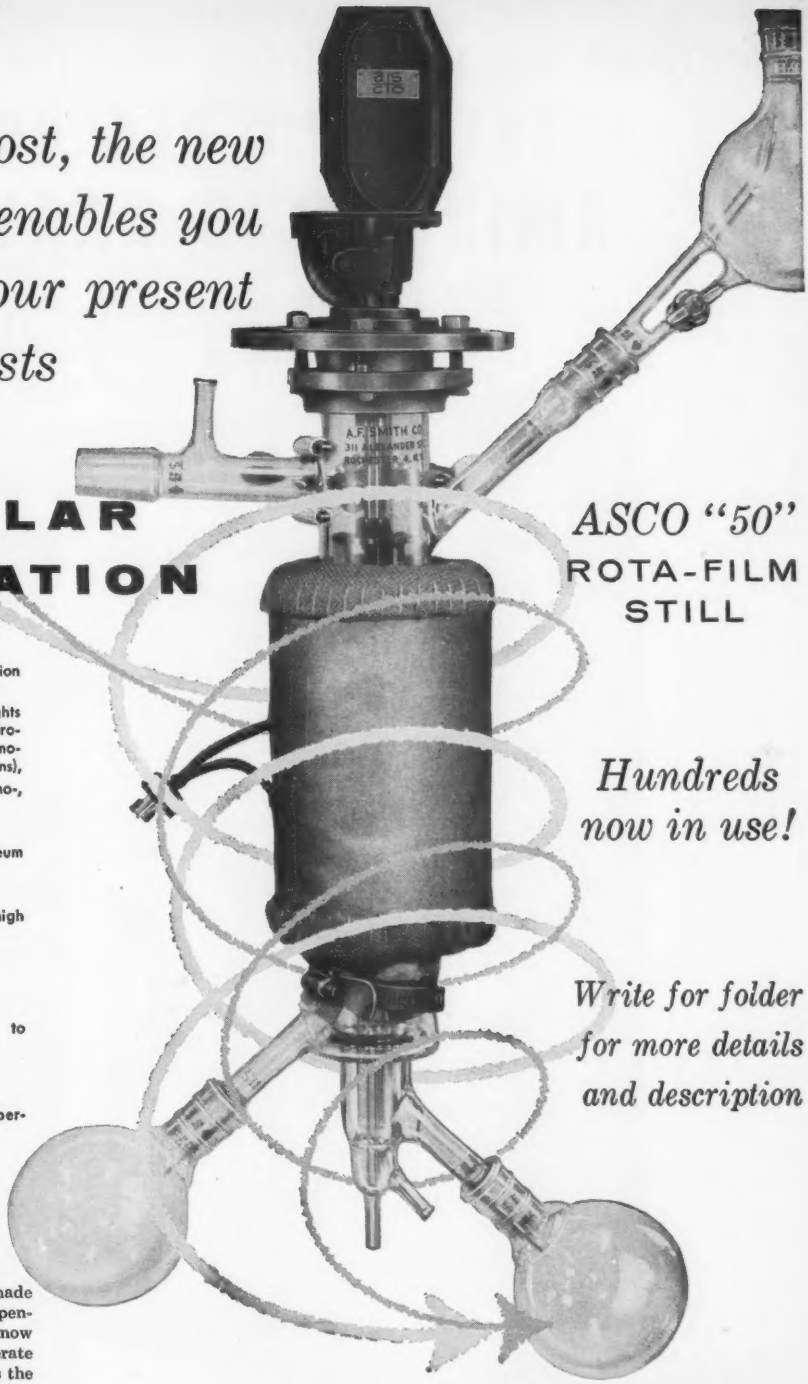

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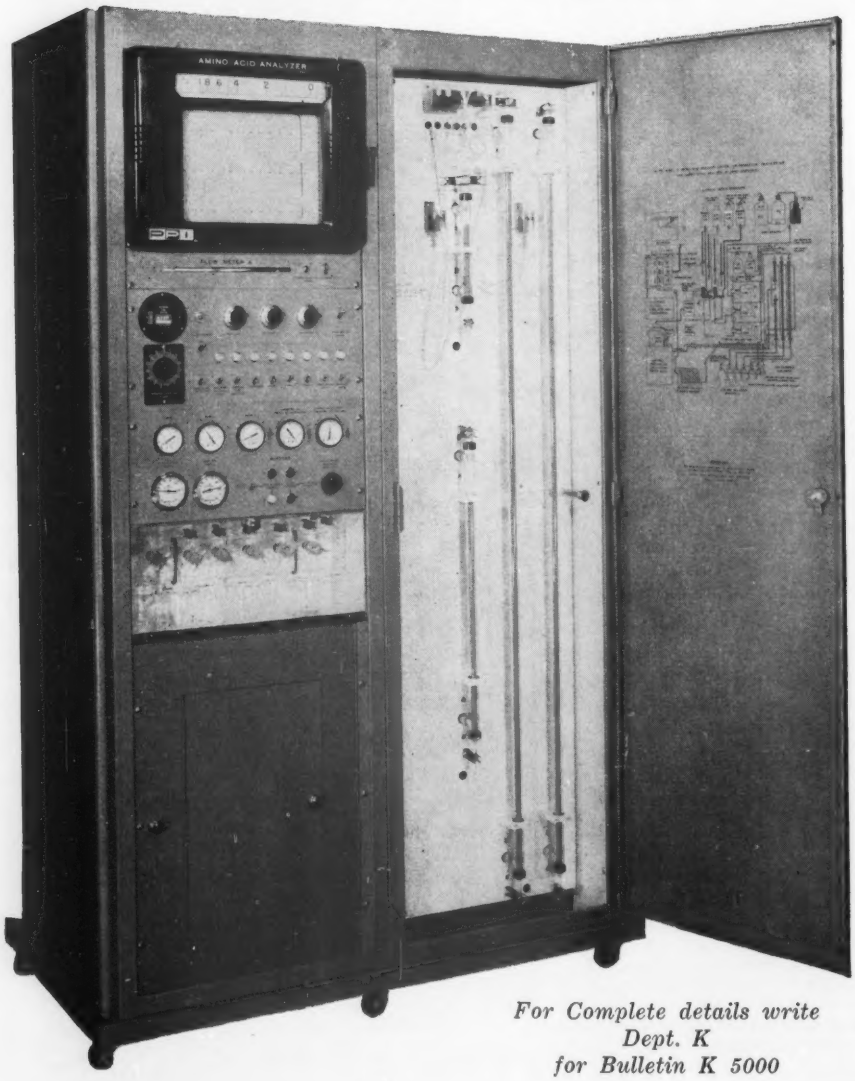

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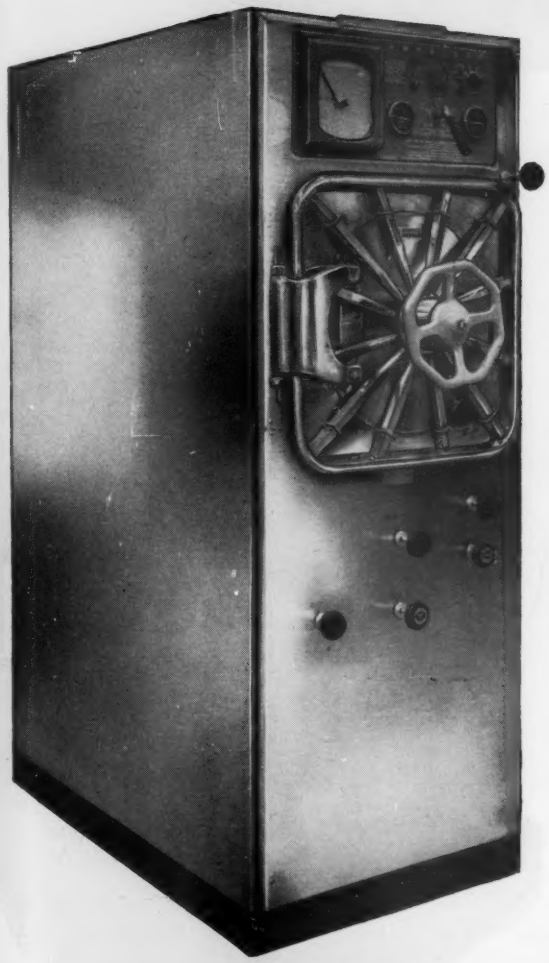

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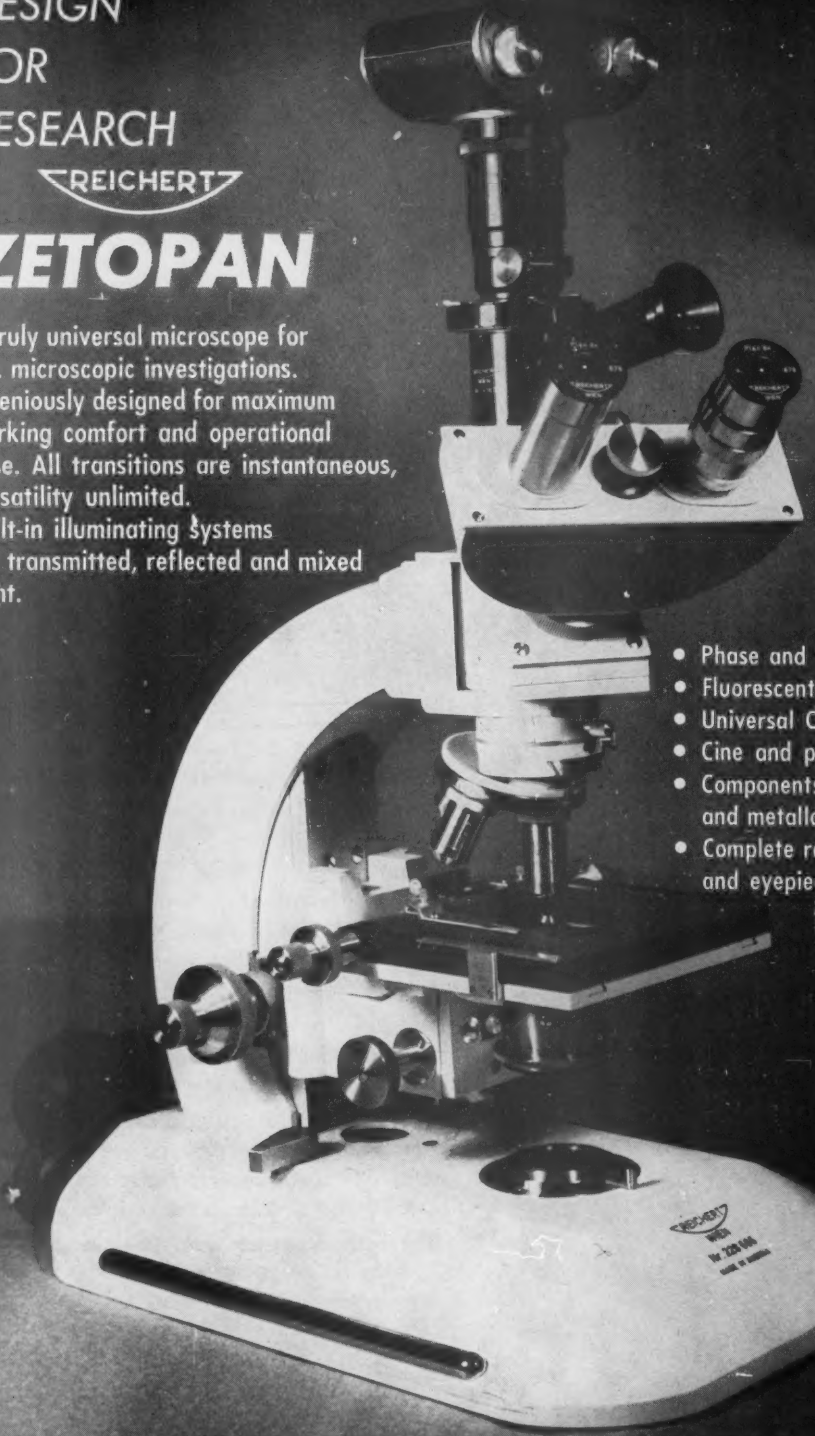

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This is the production model of the new Beckman & Whitley Model 192 Continuous-Writing Framing Camera.

Delivered to Avco Research and Advanced Development Division, outside Boston, the instrument will be used in experimental studies with high-temperature electric arcs or plasma jets, hypervelocity instrumentation, aeroballistics, and aerothermodynamics.

Shown focusing the objective lens of the newly installed camera is Glenn Hanson, head of the physics photography section of the division.

Chiefly, the advantage of the Model 192 is that it is capable of making 80 35-mm photographs of an ultra-high-speed event without the necessity of synchronizing the camera and the event. Its top operating speed is 1,400,000 exposures per second.

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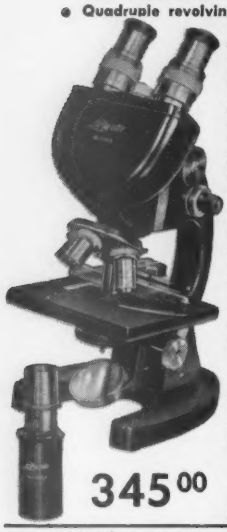
- Vernier calibrated mechanical stage
- Eight paired eyepieces
- Quadruple revolving nosepiece



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A newly developed medical—bacteriological microscope embodying all the necessary advantages that research workers find exceptionally valuable. An outstanding instrument with features of construction and design that will, without reservation, be appreciated by competent experts.

OPTICAL SPECIFICATIONS: Four achromatic, coated objectives 4X/0.15 n.a., 10X/0.25 n.a., 40X/0.65 n.a., oil immersion 100X/1.25 n.a. Eight paired eyepieces. Two each 5X Huygenian, 10X Huygenian, 15X peri-planatic, 20X Kellner. Dust proof quadruple revolving nosepiece.

BODY: Interchangeable Binocular tube inclined 45°, graduated interpupillary adjustment, left eyetube adjusts for refractive difference between two eyes. Monocular tube is extendable, graduated in mm from 140mm to 190mm. Parfocal at 170mm.

STAGE: Square stage 125mm x 130mm. Mechanical stage with 30mm x 70mm range of movement with vernier accurate to 0.1mm. Slides of practically every shape and size, including petri dishes, can be used.

FOCUSING: Coarse focus by means of coaxial rack and pinion drive on dovetail slide. Fine focus by coaxial micrometer slow motion Meyer's type adjust. Graduated 1 division equals .002mm (2 micron intervals). Spring loaded action prevents driving through subject.

SUBSTAGE: Rack and pinion driven. Double lens bright field condenser (interchangeable) 1.2 n.a. iris diaphragm. filter holder, stop against overwind, 50mm plano-concave mirror.

Satin black baked enamel finish. Chrome trim. 13¼" x 8½" x 5¼" overall. Net weight 34 lbs. Includes fitted cabinet of fine grained oak with lock and key, 5cc of cedar oil, spring clips, spanner, blue filter. Shpg. wt., 42 lbs.

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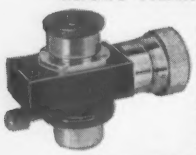
- MAKES 1 MICRON (0.0001MM) MEASUREMENTS



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Precisely constructed micrometric eyepiece required for extremely precise measurements. 10X focusing Ramsden eyepiece. When used with a 100X (oil) objective, permits measurements of 0.0001mm (1 micron). Fixed scale, 8mm long, with 1.0mm numbered graduations. Movable glass slide engraved with cross hair and 1/10 division (0.1mm) of fixed scale. The micrometer screw drum is graduated in 100 parts. Each graduation is equal to 0.01 mm. One complete revolution of the drum moves the cross hair and 1/10 division 1.00mm across the field. Complete with hardwood case. Shpg. wt., 1 lb.

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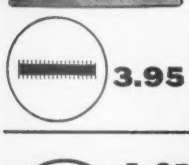
- GRADUATED TO 1/100 MM



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Measures microscope field sizes—used for calibrating and standardizing micrometer eyepieces. Fine polished glass slide, 75 mm x 25 mm, has a 1.0 mm scale with 100 graduations (0.01mm) ruled directly on it. Each fifth and tenth calibration is a larger line to aid in measurement. The lines are stained black and protected by a cover glass. Complete in hinged case. Shpg. wt., 6 ozs.

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Use these reticles to measure with extreme accuracy the length of, or the area occupied by, the smallest micro-sized specimens.

Excellent for measuring dispersion and distribution of microscopic life in their media.

Reticles mount in the ocular of the microscope; yield perfectly clear field.

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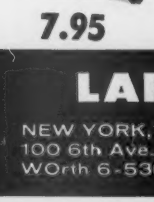

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A movable pointer in the eyepiece is visible in the optical field. Permits indication of points of interest—serves as index guide or point of reference. 8X; highly corrected, fits any standard 23mm microscope tube. Complete with case. Shpg. wt., 8 ozs.

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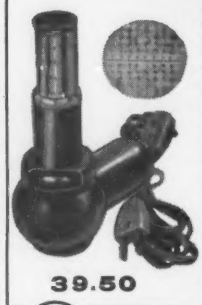

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An extremely versatile, precision microscope for use in laboratories, shop-production, field work wherever inspection or examination under high magnification is required. Adds speed to inspection. High resolving power plus exceptionally efficient illumination factor greatly increases the accuracy of all types of inspection work. Direct measuring reticle, 1mm divided into 50 parts. Permits estimates down to .0001 inch. Coarse focus by draw tube, chooses gross magnifications of 82X, 90X, 100X and 120X. Fine focus by knurled wheel and helical gear. Focusing eyepiece corrects for diopter variations. Integral light source is a 15 watt 110 v clear bulb. For field use it is interchangeable with a battery operated secondary source. High eye relief, approximately one inch, permits the operator to wear glasses. Accessory slide clips allow the examination of prepared slides while, hand holding the Opta-Scope. Eyepiece and objectives lens are standard size and readily interchangeable for variations in power. Supplied complete with 15X focusing eyepiece, 10X, 0.25na objective, blue filter, 110v. light source, battery light source, slide retaining clips, spare bulbs and fitted leather carrying case. Shpg. wt., 3 lbs.

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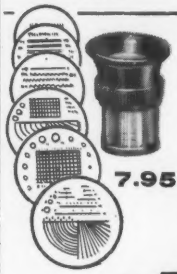
- Pocket sized Comparator
- Direct measurements to .005"!
- Measures Diameters- Radii-Angles
- Linear scale in Inches



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High quality optical micrometer using a triplet lens system of approximately 7 power. Triplet system affords a wide flat field of view. Extremely accurate reticle of etched glass. Unaffected by changes in temperature and humidity—impervious to oil, solvents and scratches. 0.5 inch linear scale calibrated to .005 inch. 10 mm scale calibrated to .2 mm. Hole diameters from 1/64" to 1/16" and from .005" to .05". Thickness scales from 1/64" to ¼". Radii from 1/16" to 3/8" and angles from 0° to 90° Measures instantly—without adjustments. Accurate to edge of 1" field. Adjustable focus. Reticle removable for use as high power magnifier. Infinite uses in lab and industry. Complete with leather case. Shpg. wt., 6 oz.

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(8) Particle measuring grid 0.4" x 0.3" subdivided to .005". Hole diameters from 0.1 mm to 3.0 mm. Radii from 1 mm to 10 mm. Angles from 0° to 90°. 10 mm linear scale calibrated to .2 mm. Shpg. wt., 4 ozs.

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- MICRO-CAMERA LUCIDA
- HIGH OPTICAL QUALITY
- EXCEPTIONAL CONVENIENCES

The Abbe type drawing apparatus can be used with any microscope having a body tube diameter of 24 mm (society size). Permits "tracing" of subject as seen in the microfield by superimposing the image on a drawing plane. High optical quality of the prism and lateral reflecting mirror gives a "projected" image of extreme brightness and clarity. Free of distortion. Calibrated, dove tailed, adjusting slide. Complete with light and dark filters and fitted wooden case. Shpg. wt., 1½ lbs.

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- ACCURATE TO 0.2%

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The first Hand Refractometer to satisfactorily fill the need for an adequate field instrument. One instrument measures all densities—0% to 90% within 0.2%. The Amici prism feature insures an exceptionally fine division of the field.

The "Tri-Plex" refractometer defines the critical line as clearly as most laboratory instruments. The tri-prism system allows the technician to choose any of three ranges at will. Reads dense or clear solutions with equal facility. The exceptionally fine optical train shows a perfectly clear, color corrected field. Small, light and exceptionally sturdy. No loose parts to become lost in field use. Extreme simplicity of operation. Shpg. wt., 1¼ lbs.

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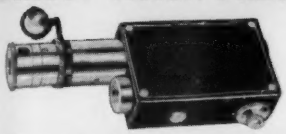

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A prismatic type, hand-held instrument that has most features of the finest standard laboratory instruments. The millimicron scale is adjustable for sharp focus and for position (with "lock-in" feature to fix scale with relation to known spectral lines). Highest grade optics yields a broad dispersion field of high intensity obtained from best quality glass dispersing prisms, while excellent lens system resolves the closest spectral lines into 2 distinct lines. By a twist of the collar, a horizontally split field is obtained by which a comparison can be made of two light sources simultaneously. Tubes and collars are constructed of highly polished corrosion proof steel. Equally suited to laboratory or field work, the spectroscope has a wide array of applications: emission spectrumanalysis of light sources; qualitative chemical analysis and metallurgical analysis by emission spectra; qualitative analysis of absorption spectra by examining aqueous or other solutions contained in the small test tubes provided. Absorption spectrum analysis has application in many branches of technology—color and dye chemistry, blood chemistry, clinical medicine, criminology. Complete with plush-lined case, shipping wt., 1½ lbs.

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- NO MOVING PARTS TO WEAR OUT
- CAN BE USED TO DETERMINE REFRACTIVE INDEX

Here is a beautifully constructed scientific tool of simple design, easy to operate, with no moving parts, except for the focusing eye piece.
Operation is very simple. A few drops of the sample are placed on the prism, the cover is closed and observation is made by means of tungsten illumination or daylight. A perfectly clear field, completely color corrected, shows a reticle graduated in percent from 0-32%. With the sample in place as described above the field will show a sharp dividing line between a bright and dark portion; where the dividing line falls determines the reading, which can be estimated to 0.1% accuracy. The instrument can be converted to a universal laboratory type by changing % readings to "index of refraction" readings, No. (Consult Chemical Handbook or literature.)
This instrument is an essential tool in the fields of sugar refining, agricultural, food technology, medicine, theoretical chemistry, etc.
Comes in a convenient portable leather case. Shipping wt., 1¼ lbs.

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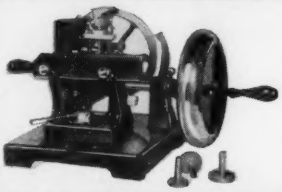

- SECTIONS 1 TO 25 MICRONS
- EXTREMELY ACCURATE FEED
- SMOOTH QUIET OPERATION
- EXCEPTIONALLY RAPID OPERATION

Used wherever extreme accuracy is required. Features a reliable, micrometer feed mechanism and exceptional stability. Can be set for sections of any thickness from 1 micron to 25 microns. Each revolution of the drive wheel completes one cutting pass. Drive wheel is heavily counterbalanced to offset the weight of reciprocating parts. The specimen holder can be positioned easily and quickly and is extremely rigid in the "fixed" position. The knife angle is readjustable and the knife is easily secured in position. The specimen holder can be locked at the top of its excursion for ease of specimen adjustment. The micrometer feed screw, indexing head and other movable parts are readily and precisely adjustable. This microtome is capable of exceptionally rapid sectioning of specimens while maintaining an extremely high degree of accuracy. Where practicable the parts are of stainless steel, nickel silver, or heavily enameled to prevent corrosion and discoloration. The instrument is supplied with a section carrying belt, a 150mm Minot type knife, 3 specimen supports, leather strop, honing bevel, stropping paste and case. Shpg. Wt., 75 lbs.

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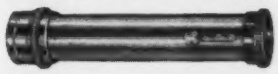

Every physics, chemistry, science class, or hobbyist can afford to own this superb instrument. It is the simplest means by which one can observe emission spectra from light sources and vaporized chemical salts, and the Solar Spectrum.
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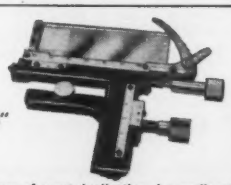

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- LOCATES ANY SPOT ON A SLIDE, "ON THE NOSE"
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Locates any spot on a microscope slide with perfect assurance of exact duplication, by reading the coordinates of the horizontal and vertical scales. The horizontal scale is engraved from 40 to 100 mm; with Vernier. Vertical scale is engraved from 0 to 40 mm, with similar Vernier. No error is possible when recording the co-ordinates for location of a point on the slide. The stage has a spring clip that automatically fits the slide into the proper position on the stage.
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Automatic Super-Speed REFRIGERATED CENTRIFUGE

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The model LRA is the first automatic refrigerated centrifuge of its kind. Like the non-automatic Model LR, it has the newest and most efficient refrigeration design ever introduced. By proper placement of cutouts, baffles and deflection plates, a smooth forced air circulation system is set up. The warm air coming off the rotor flows around large surface area cooling coils on the side and bottom of the chamber. Upon emergence in the cooled form, the air flows onto all portions of the rotor. This system permits the cooling of any Lourdes' rotor from ambient to 0°C within ten minutes by spinning at slow speed. Rotor temperatures are easily maintained at 0°C and lower during full speed extended runs, and as low as —15°C at lesser speeds or for shorter runs.

By merely throwing a toggle switch, a 1 Hp. motor automatically accelerates any rotor to a pre-set speed . Lourdes' electrodynamic push-button braking system provides for smooth rotor stopping in a fraction of unbraked stopping time. A time delay relay releases the braking action at slow speed and permits the rotor to stop naturally without disturbing the sediment. This same centrifuge is now available with a ½ Hp. motor drive (Model LRA-1) to provide higher speed and force with the smaller rotors.

Each centrifuge comes adapted to accommodate the new Lourdes' continuous flow system at no additional cost. The continuous flow rotors with polyethylene liners, in addition to ease of operation, assembly and disassembly, also offer fast flow rate, high speed and force and greater collection capacity than any comparable continuous flow centrifuge. New time saving applications for these rotors are being discovered daily.

Every Lourdes' instrument is guaranteed for a period of one year and this guarantee insures customer satisfaction.

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Technician is setting controls for the assaying run. Picker equipment (left to right) Magnascaler, (below it) High Voltage Supply, Automatic Sample Changer with Detector, Readout Printer.

PICKER nuclear instruments

takes time and labor out of a tedious job

If you are doing blood-brain barrier studies in order to investigate how different drugs get into the brain, you will probably be using many rats, guinea pigs, or monkeys. Each of these test animals will ultimately have to be sacrificed for brain dissection. Then, if you have used Carbon^{14} or Phosphorus^{32} to tag the drugs, each brain section (cortex, cerebellum, etc.) will have to be counted. In such cases the use of an automatic sample changer not only saves many hours of a technician's time but also improves the accuracy of the measurement by furnishing printed data.

Picker can supply a highly reliable system for automatically counting up to 30 samples and for recording either the time required for each sample measurement to achieve a preset number of counts, or for printing both the counting time and accumulated counts for each sample.

The Automatic Sample Changer is representative of the comprehensive Picker line of quality nuclear instrumentation.

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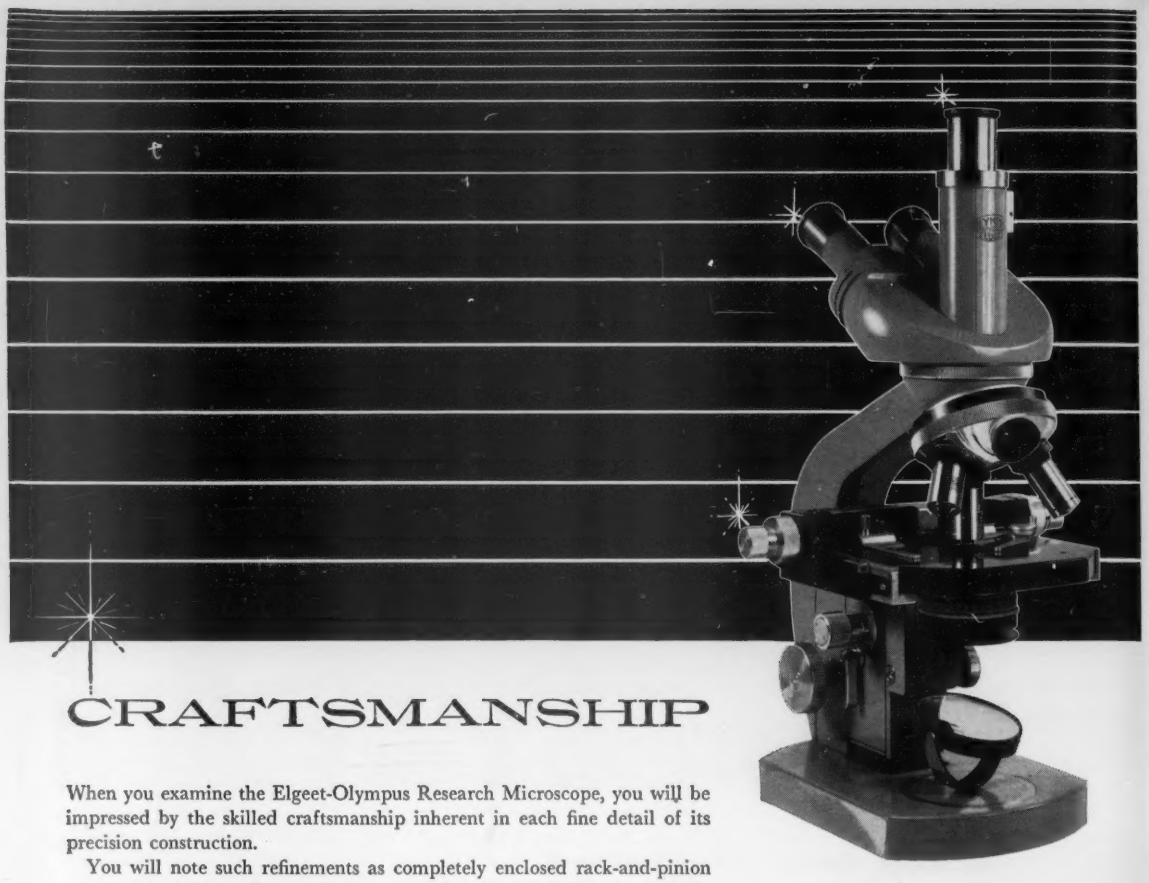

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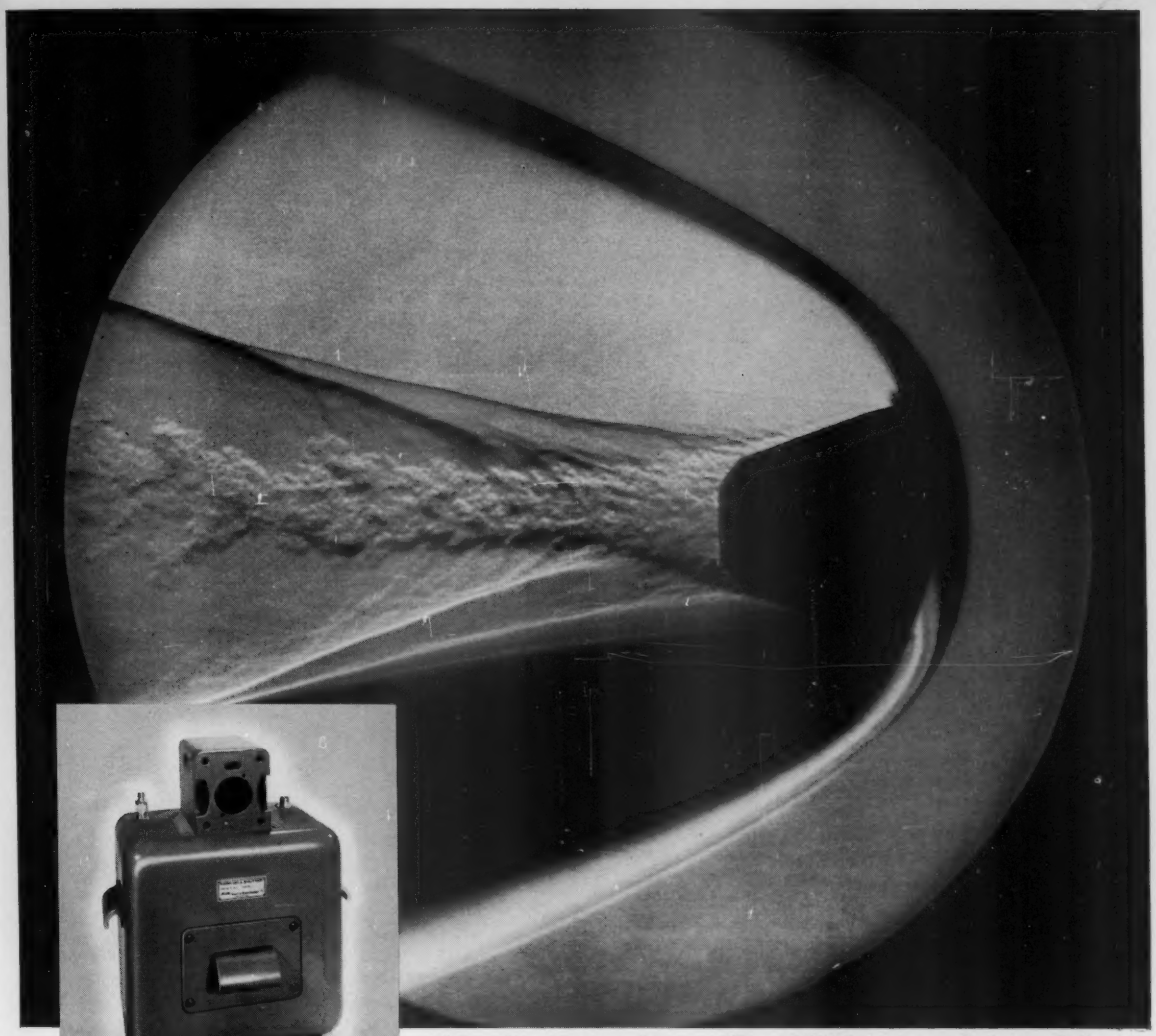

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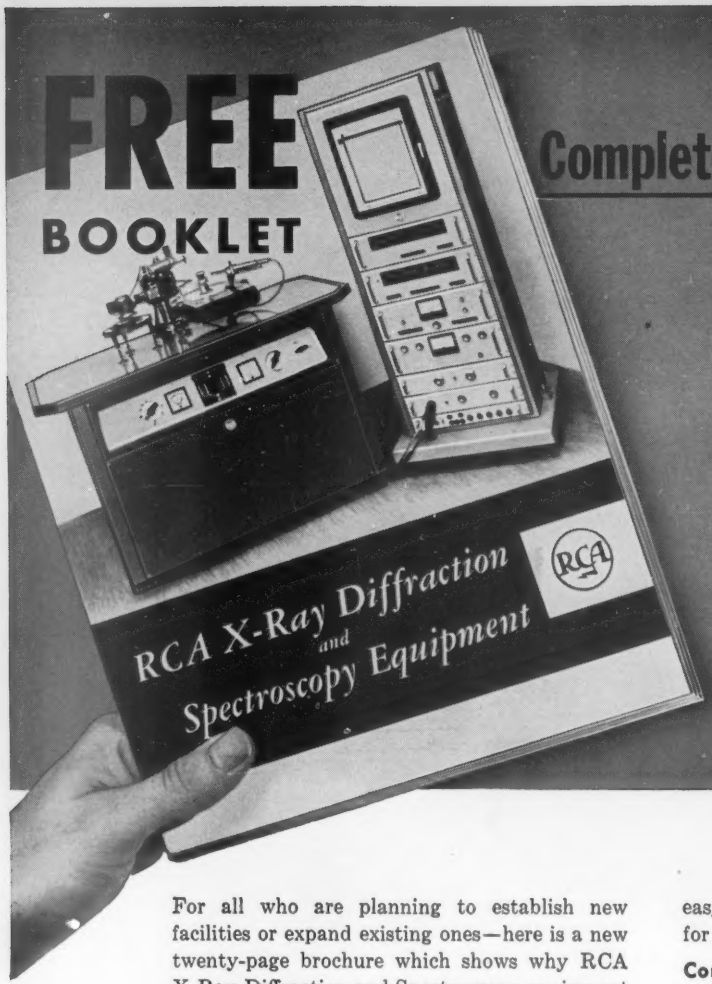

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With Torsion's new 500 gram capacity balance you can make three times as many weighings per hour as before. Here's why:

Conventional laboratory balances use a graduated beam and slide weight for "fine" weighing after the weight has been determined to within 10 grams. Under the old procedure the balance is arrested, slide weight positioned, balance released, balance comes to rest, position of indicator noted, balance arrested again, slide weight repositioned and so on until the weight is determined within 0.1 gram.

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Torsion Laboratory Balance DLT5
Capacity: 500 grams
Readability of Dial: .02 grams

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Model DLT2
Capacity: 120 grams
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Same specifications as DLT2 but has scoop for seeds or other bulky material.

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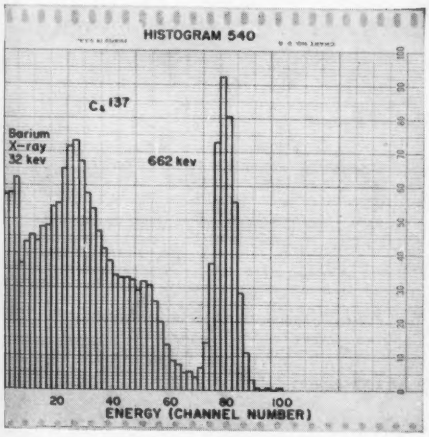

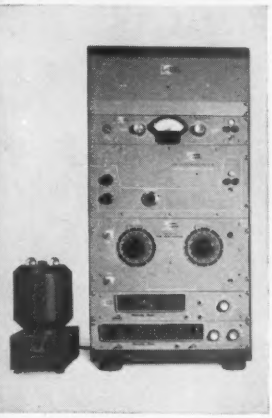

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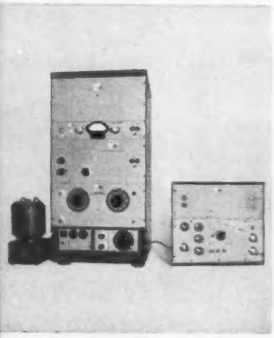

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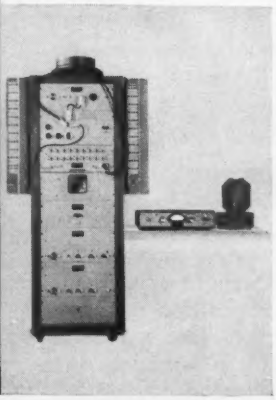

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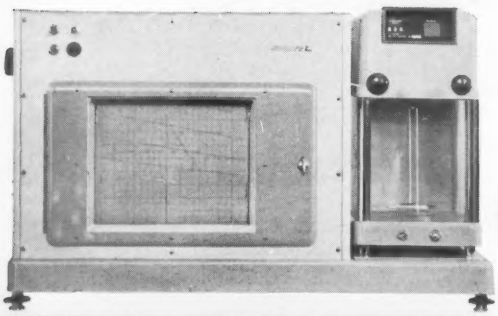
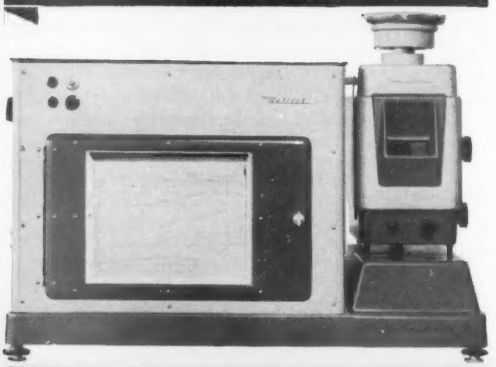
TWO NEW METTLER RECORDING BALANCES

based on photoelectric scanning of the beam position



TYPE R5 H4/21



TYPE R5 K7T/21

Photoelectric scanning, with a beam of light representing the only link between the moving balance beam and the recording unit, avoids any interference of the recorder with the vitally essential free movement of the beam. Precision and accuracy of the weighing unit are fully maintained and faithfully reproduced.

TYPE R5 H4/21

Weighing range: 160 g

Recording range: 1.02 g
corresponding to the optical range of the balance.

Recording accuracy: ±1 mg

Balance: *analytical type, weighing by substitution, pan enclosed in balance housing.*

TYPE R5 K7T/21

Weighing range: 800 g

Recording range: 102 g
corresponding to the optical range of the balance.

Recording accuracy: ±0.1 g

Balance: *precision type, weighing by substitution, pan unobstructed on top, built-in taring device with 100 g range.*

Both types can be equipped for weighings below the balance, such as in an oven.

The new recording balances will be a part of the interesting display of new items to be presented by METTLER at booth No. 339, 27th Exposition of Chemical Industries, Coliseum, New York, Nov. 30 – Dec. 4, 1959. If you cannot visit the show, write to us for full information.

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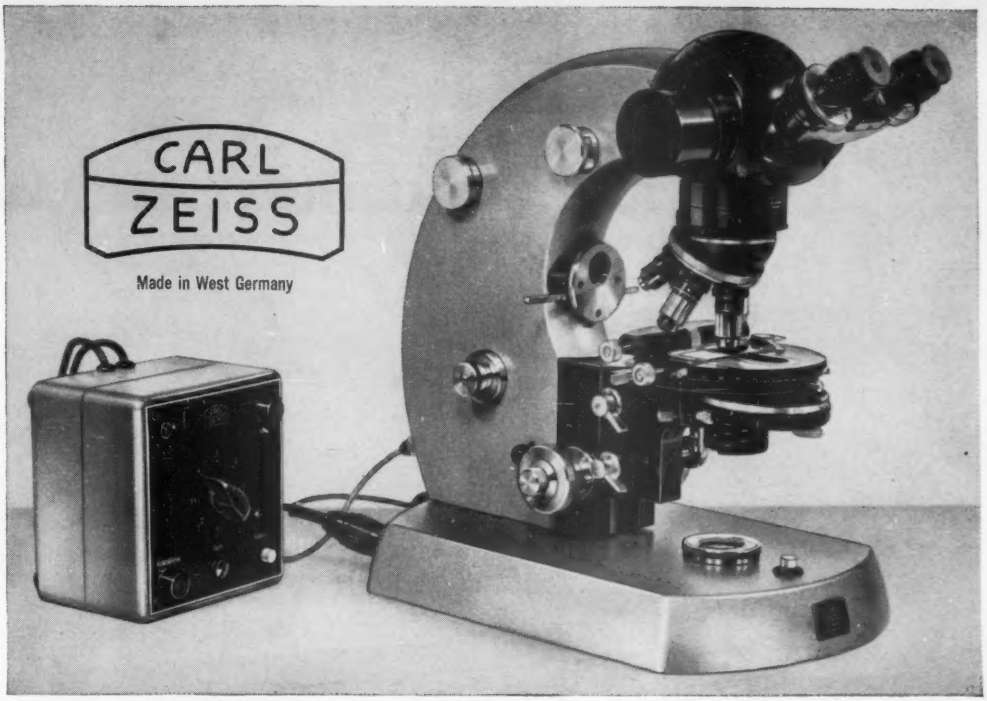

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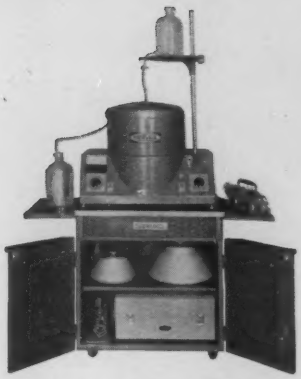

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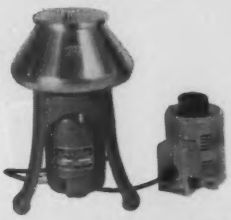
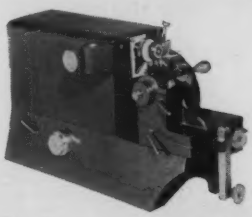


SS-1 Superspeed Centrifuge—adaptable for Continuous Flow System

SS-4 Enclosed Superspeed Centrifuge with control panel removed for remote control operation



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PAGES 1027-1028, READERS SERVICE CARD

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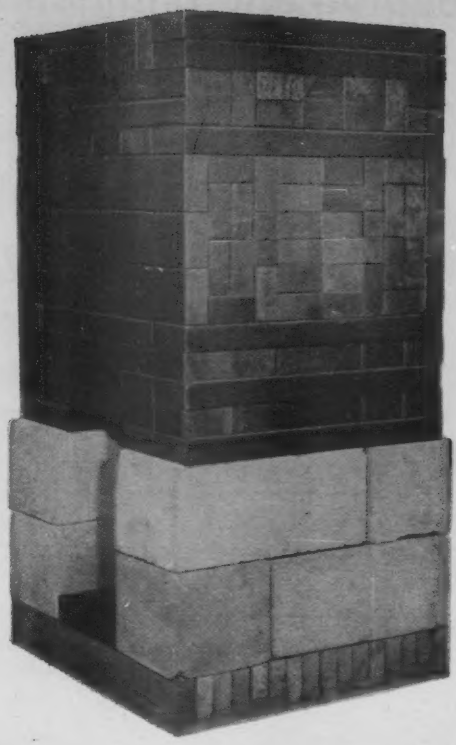
may require especially reinforced floors; cost approximately $800.00; and are altogether superfluous with the availability of the new **Amperex®** *Type 18515/Type 18517 Low-Level Beta Counter*



In recent years, the measurement of low level radiation has become increasingly important, particularly in connection with the radioactive contamination of the atmosphere, water supplies, foodstuffs, and the waste material from medical, radio-chemical and nuclear laboratories. Hence, an acute need has developed for a reliable, ultra-sensitive Geiger counting system which combines accuracy and compactness at a moderate cost.

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By virtue of its unique design, the beta detection efficiency of the Amperex 18515 beta tube greatly exceeds that obtained by any previous halogen-quenched, thin-window tube.

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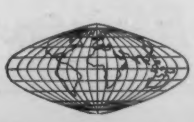
To reduce the effects of radioactive contamination, utmost care has been taken in the selection and processing of all materials used in the fabrication of these tubes.

The type 18515 can be supplied with a mica window 1.5–2 mg/cm², or, where a further reduction of background is required, with a steel foil window 8 mg/cm².

Thus, AMPEREX, first to manufacture production quantities of Geiger-Muller tubes with completely uniform and predictable characteristics, and subsequently, pioneers in the development and mass production of stable, unlimited-life, halogen-quenched Geiger tubes, has again turned its 'proprietary' manufacturing techniques to the implementation of a significant new development in radiation measurement from the research laboratories of Philips of the Netherlands.

For additional information, write to Semi-Conductor and Special Purpose Tube Division, Amperex Electronic Corporation, 230 Duffy Avenue, Hicksville, Long Island, New York.



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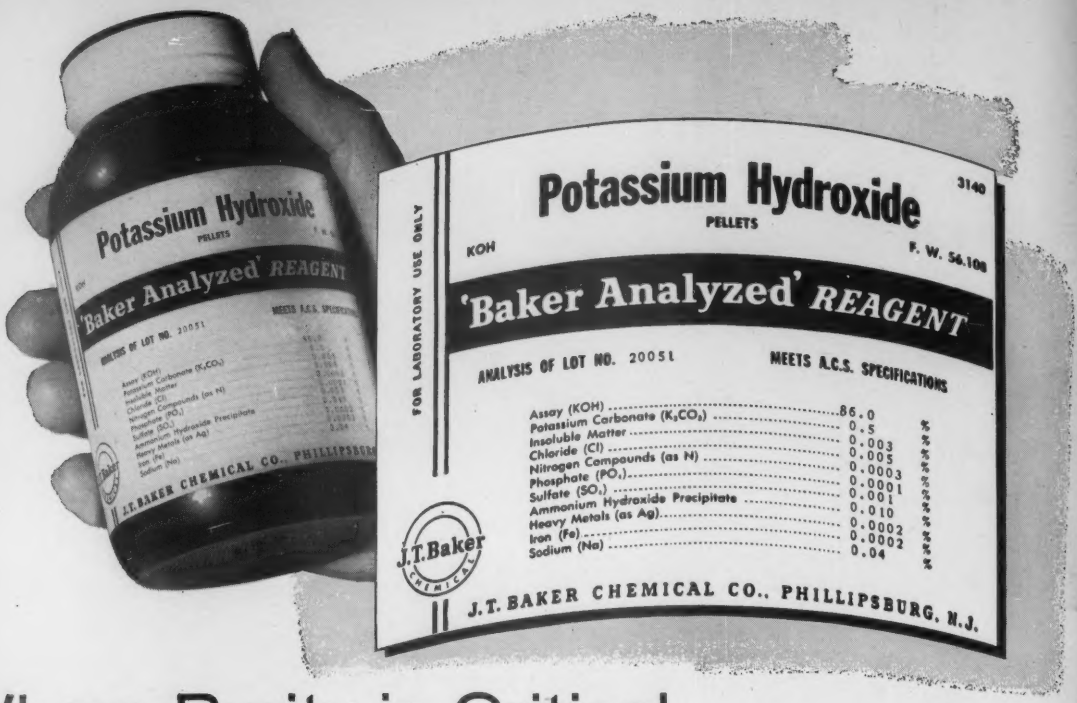

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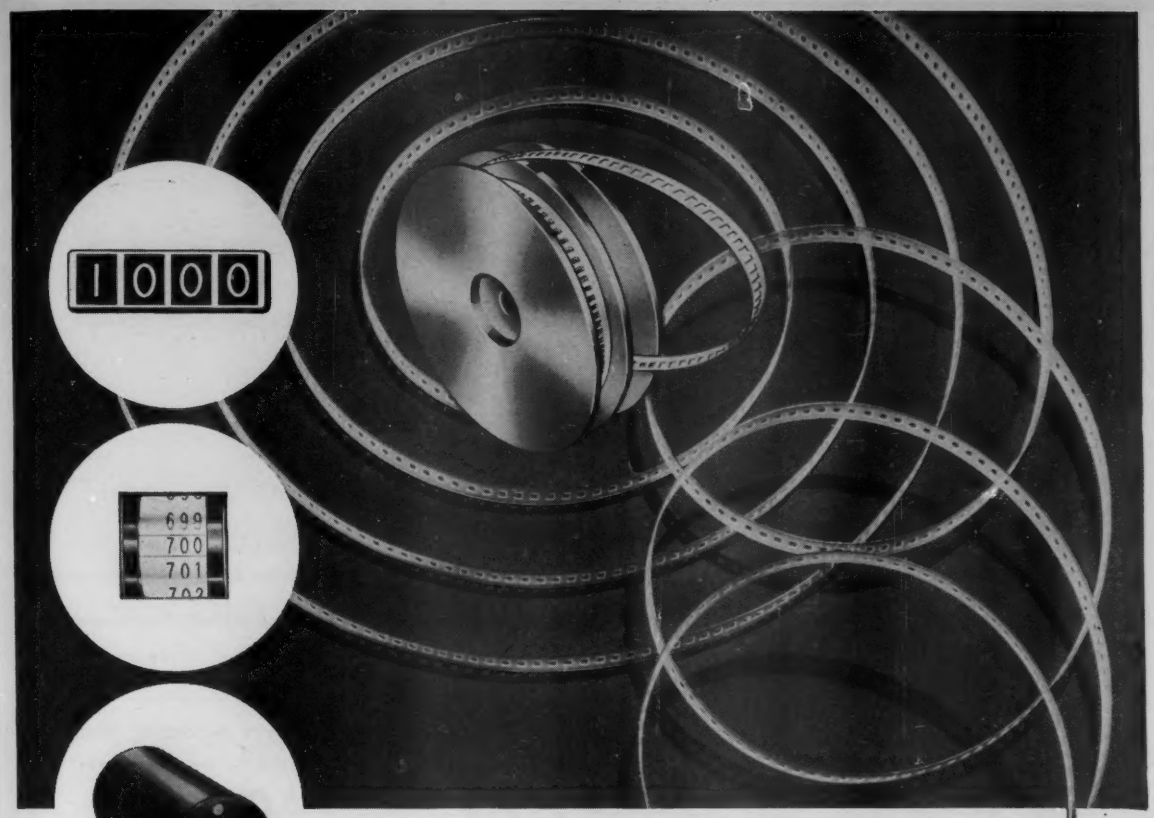

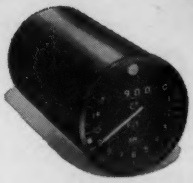

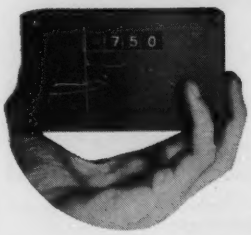

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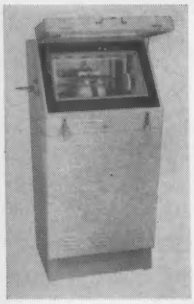

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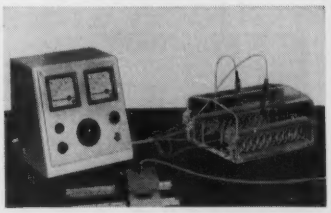

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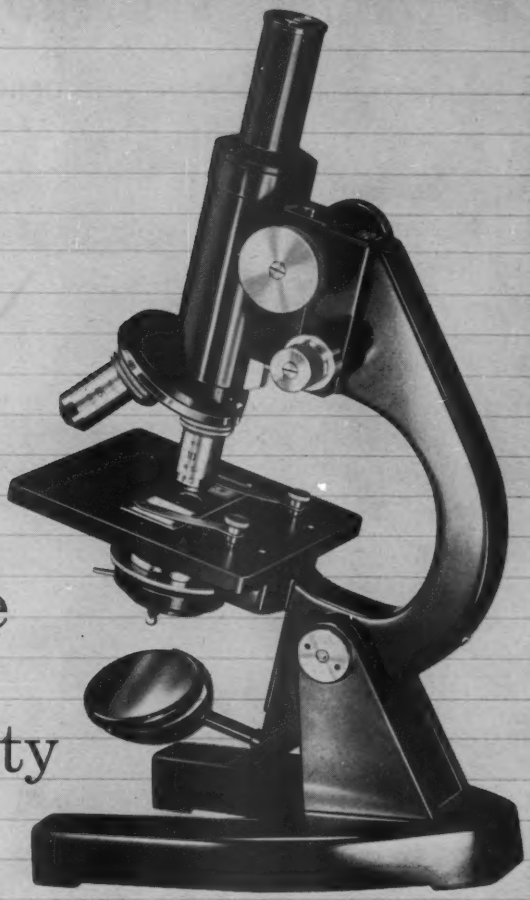

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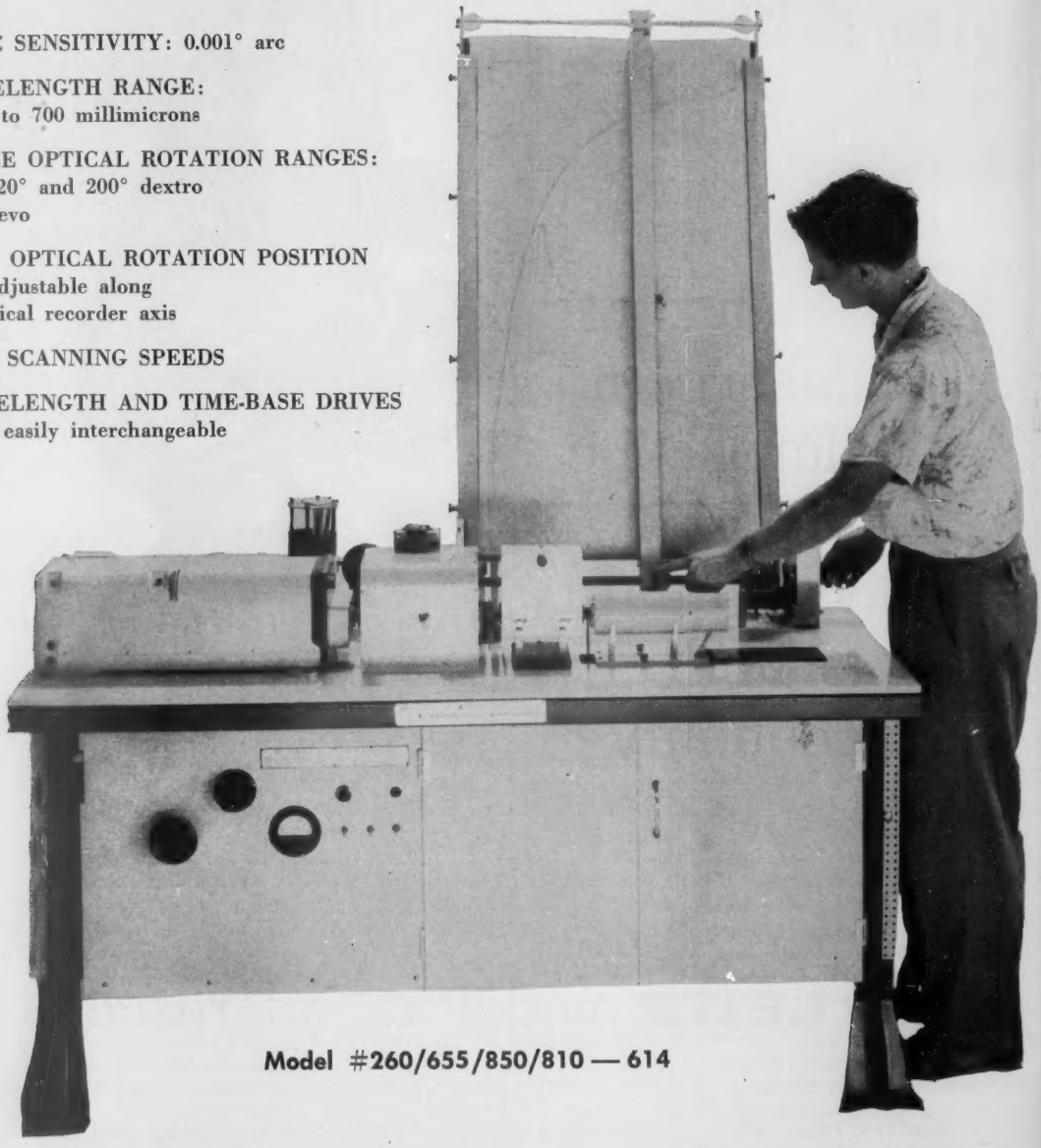

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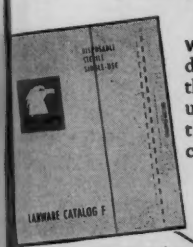

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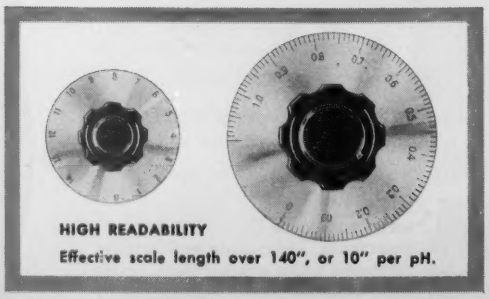

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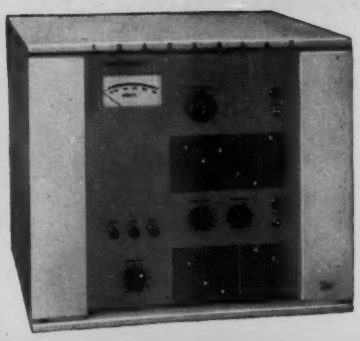
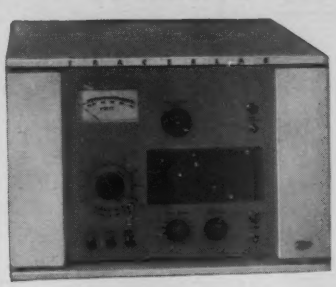


SC-73 Versa/Matic II Scaler



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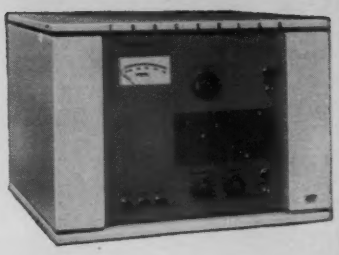

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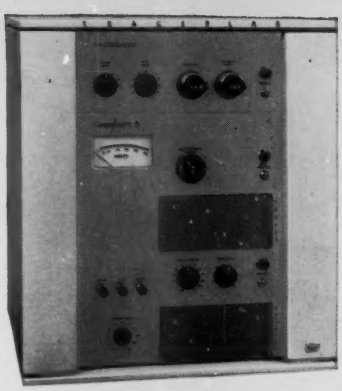

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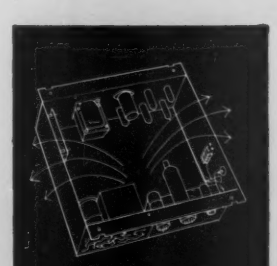

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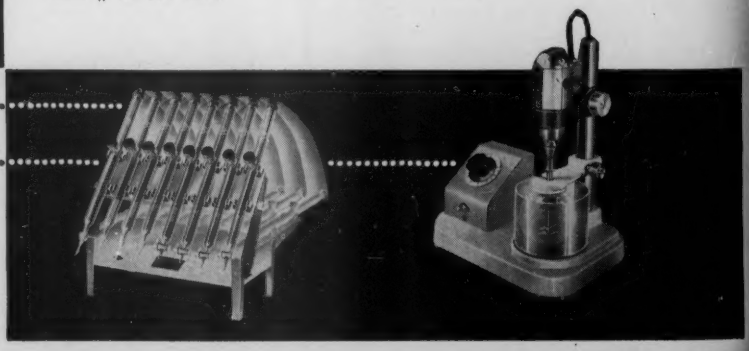

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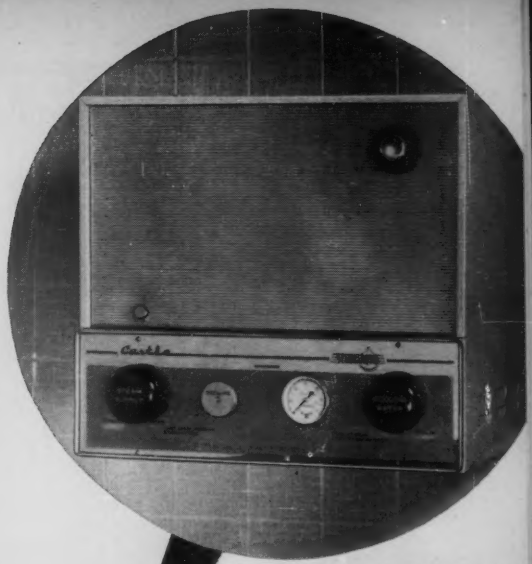

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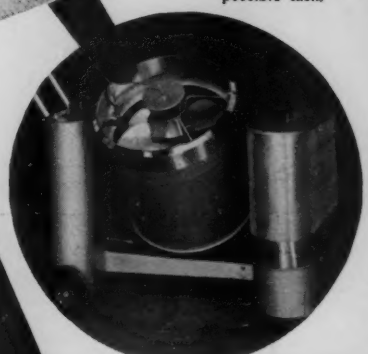

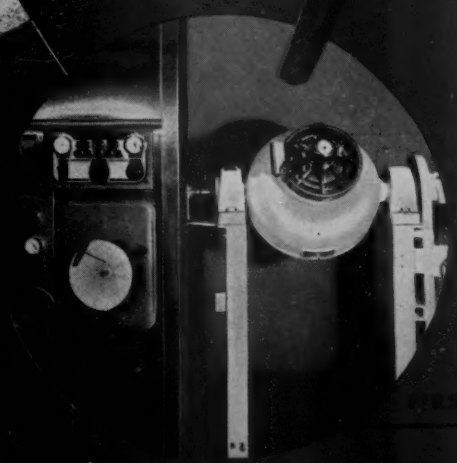

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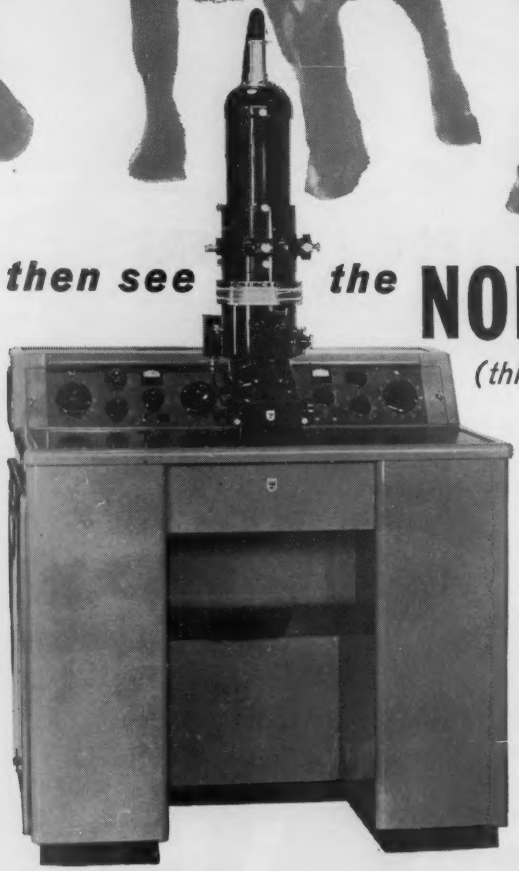

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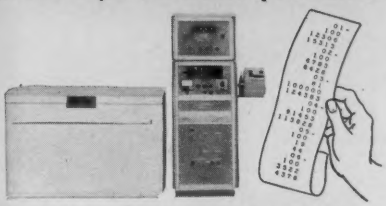

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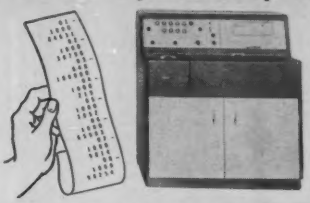

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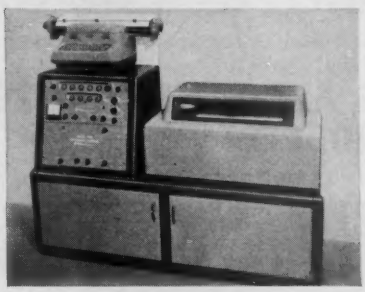

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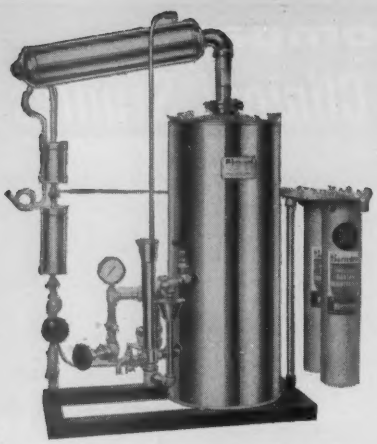

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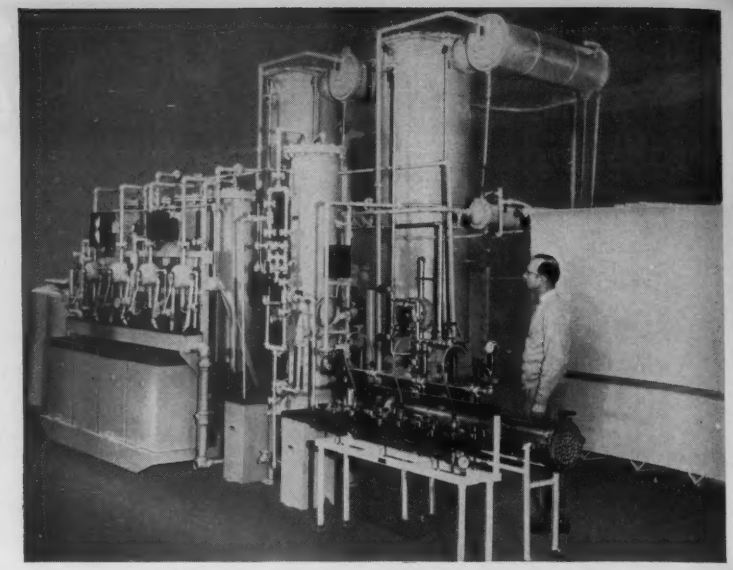

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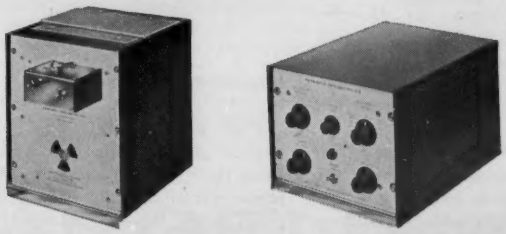

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Letters

Science in Spain

We find to the point much of the information provided by A. G. Verduch [*Science* **130**, 126 (1959)] in his comments on the article by David Gates on basic research in Europe [*Science* **128**, 227 (1958)]. But, although Verduch's comment on Spain is brief, it conveys the idea that research in Spain is "free"; that there is a free exchange of theory, methods, and ideas, when it is common knowledge that there exists a censorship which makes it difficult to receive information in such fields as political economy, evolution, and sociology.

Although much good work is actually done in Spain by our colleagues in the field of anthropology, this cannot, probably, erase the effects and norms of the regime. A few examples will suffice.

From *Manual de Antropología* (1946), by Pérez de Barradas, professor in anthropology: "There are anthropologists who still cannot do away with the evolutionist load" (page 12); and, "We think anthropology as a science should abandon the theme of the origin of man, and gallantly confess that it is not known when, where, or how man appeared on the earth, and also the utter failure of evolutionism" (page 25).

In volume 1 (1954) of the ten-volume *Historia Universal*, edited by S. A. Espasa-Calpe (one of the most renowned editors of Spain, if not the most renowned), in the chapter "The birth of humanity," there is a strong criticism of Weidenreich in which it is stated (page 101): "Today no one believes that man comes from an animal world of ancestors," and so on.

B. Melendez, professor of paleontology at the University of Madrid, and director of the department of paleontology of the National Museum of Natural Sciences, in the prologue to the book *Hacia el Origen del Hombre* (1956), by Valeriano Anderez Alonso, writes the same sort of equivocal concepts: "Organic evolution *within certain limits* [our italics] is a historical reality," and so on.

Since this is "Darwin's year," it seemed pertinent to us to provide the foregoing information and to give examples of the regrettable conditions that unhappily prevail in much of Spain's scientific life.

JUAN COMAS
T. SANTIAGO GENOVES
Instituto de Historia,
Torre de Humanidades,
Ciudad Universitaria, Mexico City

The Green Ray

Gerhart S. Schwarz says that the green ray can be seen only from an elevation but does not say how great an elevation [*Science* **130**, 276 (1959)].

I formerly had a shore cottage on the northwest shore of Oahu, and I have seen the green ray several dozens of times when my eyes were about 16 feet above sea level.

I have also seen the green ray from shipboard between Honolulu and California, in the North Atlantic Ocean, and in the Adriatic Sea.

Most remarkable, however, was seeing the green ray once from the observation platform at the rear of an eastbound train somewhere on the Great Plains.

HAROLD S. PALMER
Honolulu, Hawaii

In his letter concerning the green flash, Gerhart S. Schwarz says, "the green ray can be seen only when one views the horizon from an elevation, and this . . . plus factors of latitude, season, and weather . . . probably explains why few sea captains are familiar with it." This comment is misleading, for I have seen the green flash many times while sitting or standing on a beach or the deck of a ship. I have seen it also from planes and from mountain tops, and in latitudes from the Tropic of Capricorn to the Arctic Circle.

From an elevation, the green flash may at times be seen *before* the sun sets. On such occasion, two notches may be seen on the sides of the sun, and these two notches coming together at the top of the sun result in a green flash.

One may reasonably look for the green flash at sunset whenever one has a clear horizon to the west, and sea captains should have many opportunities to observe it.

CHARLES H. SMILEY
Ladd Observatory, Brown University, Providence, Rhode Island

Stratospheric Fallout

Fry and Kuroda have recently studied stratospheric fallout, using the ratio Ba^{140}/Sr^{89} as a parameter. Their report [*Science* **129**, 1742 (1959)] appears open to serious objection. The basis of the authors' thesis is their assumption: "Since the fission products remain in the troposphere for only a month or two, the fallout since December or January must have originated almost exclusively from the stratosphere." This assumption is not estab-

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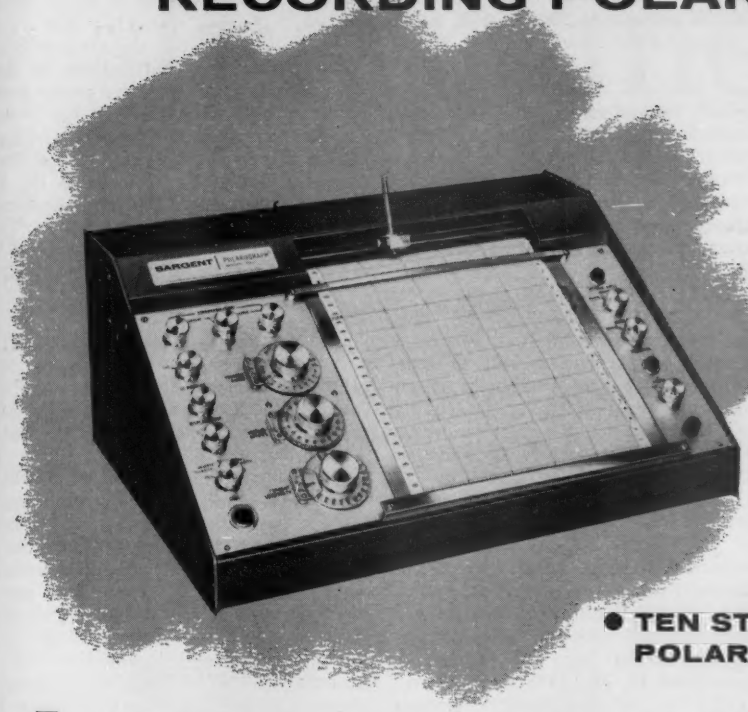

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lished; Machta, for example, in testimony before the Joint Congressional Committee on Atomic Energy (5–8 May 1959) states that *half* (my italics) of the tropospheric activity falls out every month. The clearing of the troposphere, with a 30-day half-life, cannot be considered complete while there is still measurable Ba^{140}, with only a 13-day half-life. Equation 1

$$[Ba^{140}/Sr^{89}]_R = ke^{-(\lambda_{140}-\lambda_{89})t}$$

which the authors use to describe their experimental results, can be derived solely on the basis that the contributions of the October-November 1958 test series, whether stratospheric or tropospheric, were in very large excess over pre-existing pools of Sr^{89} and Ba^{140}.

The extrapolated value of the Ba^{140}/Sr^{89} ratio (5.5 on 25 Oct. 1958) must be considered fortuitous, inasmuch as there is no particular reason to extrapolate to that date. An equally reasonable extrapolation might be to the middle of the U.S.S.R. test series, say 18 Oct. 1958, which would give an extrapolated Ba^{140}/Sr^{89} ratio of 7.3. The Ba^{140}/Sr^{89} ratio (5.5) in freshly produced U^{235} fission product mixture is not necessarily appropriate to weapon test fallout, which may well be derived from fission of Pu^{239} or U^{238}. The Ba^{140}/Sr^{89} ratio in fission product from either of these materials would be greater than that from U^{235} [S. Katcoff, *Nucleonics* **16**, 78 (1958)].

A. S. GOLDIN
Division of Radiological Health, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio

Goldin claims that the basis of our thesis is the assumption: "Since the fission products remain in the troposphere for only a month or two, the fallout since December or January must have originated almost exclusively from the stratosphere." First of all, we wish to set the record straight by pointing out that such an assumption is neither necessary nor was it used either in deriving Eq. 1 or in arriving at the final conclusion.

As to the validity of the above statement per se, we might mention that Kuroda [*ANL-5920* (Oct. 1958), pp. 1-40] has estimated that 94 percent of the total Sr^{90} fallout was stratospheric during the period between 15 Oct. 1957 and 1 June 1958, at Lemont, Ill. In view of the fact that many nuclear explosions occurred during the above-mentioned period, whereas there was no explosion after the fall of 1958, it would be surprising indeed if the percentage of stratospheric fallout in the total fallout after December 1958 were not much higher than that in 1957–58.

In regard to Goldin's concern over "the clearing of the troposphere," we would like to emphasize the fact that our method is designed to work when "the clearing of the troposphere" is incomplete, as well as when it is complete. We have done this mathematically. Equation 2 leads to Eq. 1 when $A^*_{T,0} >> A_{T,0}$ and $A^*_{S,0} >> A_{S,0}$—that is, when both the stratospheric and tropospheric contributions of the test series are in very large excess over pre-existing pools of Sr^{89}. It has to be noted that this occurs regardless of the value of the $e^{(k_T-k_S)t}$ term in Eq. 2. We might add that Eq. 2 leads to Eq. 1 also, if either one of the following conditions is fulfilled:

$$A_{S,0} = 0 \text{ and } B_{S,0} = 0 \qquad (I)$$

or

$$A_{T,0} = 0 \text{ and } B_{T,0} = 0 \qquad (II)$$

However, none of these terms can be assumed to have been zero during the period between the fall of 1958 and the spring of 1959.

It is an oversimplification for Goldin to say that Eq. 1 "can be derived solely on the basis that the contributions of the October-November 1958 test series, whether stratospheric or tropospheric, were in very large excess over pre-existing pools of Sr^{89} and Ba^{140}." Such an approach limits the usefulness of Eq. 1 and can result in additional confusion. We can demonstrate a good example of this in Goldin's next objection, concerning the extrapolation of the data.

To extrapolate the data, as Goldin suggests, to some earlier date would be meaningless because the stratospheric inventories of Ba^{140} and Sr^{89} have undergone considerable change between, say, 18 and 25 October, due to (i) new and undefined additions to the stratosphere during this time, (ii) radioactive decay, and (iii) fallout. After 25 October any changes were due to (ii) and (iii) only, which were used in deriving Eq. 2. The derivation of Eq. 2, however, does not take (i) into account, and any mechanical extrapolation of data not supported by theory only invites error in conclusions. Any extrapolation beyond 25 October will contain the error of disregarding the important factor (i).

Kuroda has explored the effect of fission of some materials other than U^{235} on the ratios of radionuclides, as suggested by Goldin. Our present data do not indicate that other materials were used, nor do they rule out this possibility.

LOIS FRY
P. K. KURODA
Department of Chemistry, University of Arkansas, Fayetteville

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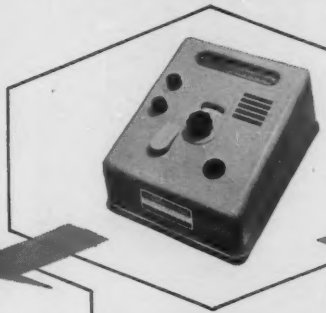

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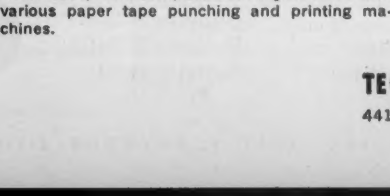

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Through the Bamboo Curtain

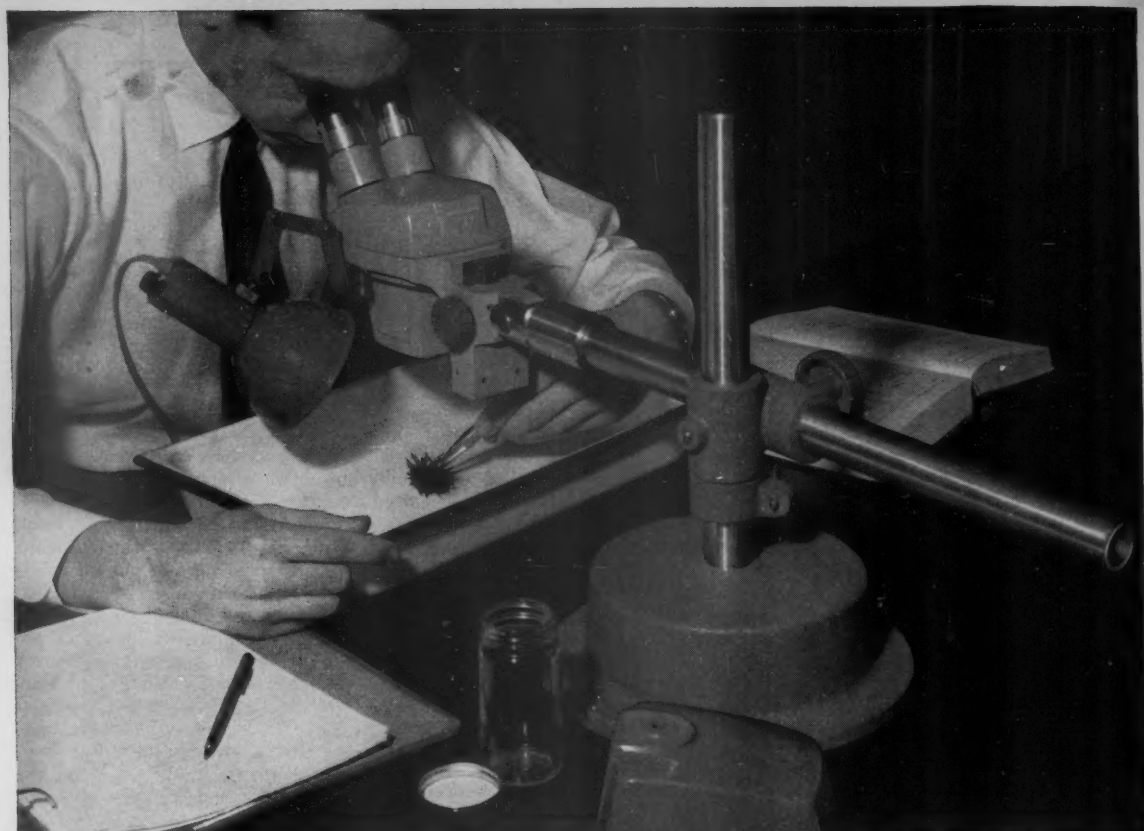
The United States policy of not extending diplomatic recognition to certain countries, most notably East Germany and Communist China, is bolstered by efforts to prevent the development of trade and cultural relations with those countries.

Prior to the Geneva conference of 1955, these corollaries of our policy greatly limited our ability to obtain scientific books and periodicals from the nonrecognized countries. Treasury licenses for import or exchange were difficult to obtain and permitted only small acquisitions; the Customs Bureau, acting for the Post Office at points of entry, often delayed and sometimes prevented the delivery of scientific publications to legitimate scholarly institutions in the United States; and the Department of Commerce was reluctant to issue import and export licenses for scientific publications. In practice, the policy limited U.S. consumers of scientific information almost entirely to the purchase of materials that found their way into the world markets of cities such as Hong Kong, Tokyo, London, and Bonn.

Since the Geneva conference, perhaps as a result of representations to the State Department by scientists and librarians, there has been a quiet and unpublicized change in both attitude and practice on the part of the several government agencies that control the flow of scientific information between the United States and the nonrecognized countries. The Treasury has made licenses for purchase and exchange more readily available than in the past; the Customs Bureau now seldom blocks delivery of incoming scientific material; and the Commerce Department readily grants import licenses and has established a general export license that automatically applies to scientific information (but not to technological material unless it is freely available in this country).

Thus, nongovernmental libraries, abstracting services, and scientific academies can, though with some difficulty, directly negotiate for the materials they want from the countries in question. The case is different for government scientists and the government libraries that constitute our great national scientific libraries—the Library of Congress, the National Medical Library, and the Library of the Department of Agriculture. For them, the old obstacles still remain to a considerable extent. Government officials are not permitted to correspond directly with officials in the nonrecognized countries, nor may they enter into direct arrangements for purchase or exchange. Consequently, they either continue to depend upon purchases made outside the countries in question, as does the Library of Congress, or to work through third parties such as the Academy of Sciences in Bonn and private university libraries, as does the National Medical Library. Such third parties can deal directly with people in East Germany and Communist China for purchase of books and periodicals. They may not, however, enter into exchange agreements for their principals. This is a heavy handicap, for the national libraries depend on exchanges for a large fraction of their accessions; the Library of the Department of Agriculture, for example, receives more than 17,000 periodicals by exchange.

Although much has been done to ease the flow of scientific information from the nonrecognized countries, much remains to be done by way of working out satisfactory means of getting such information without jeopardizing the over-all national policy.—G.DuS.



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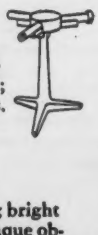

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Study of Fast Events

Very fine time resolution can be obtained with techniques used in research on explosives.

Wendell G. Sykes

During World War II a great deal of research effort went into the development and improvement of weapons in which chemical and nuclear explosives were used. Of necessity, an appreciable part of this effort was devoted to the improvement of techniques for the study of very fast phenomena associated with explosions. Since the war, research on very fast phenomena has continued, with two important changes: workers in this field have greater freedom to publish their techniques (if not always their results), and important nonmilitary research has been done in the fields of nuclear fusion and the properties of materials under extremely high pressures.

Since many of the methods developed for the study of high-speed phenomena are not well known, this article attempts to provide a general summary of these techniques in the hope that they may prove interesting to workers in other fields (*1*).

Nonluminous Subjects

A camera is about the most useful instrument in the study of fast events, and a considerable number of cameras have been developed with very short effective exposure times. Probably the simplest types of high-speed cameras are those capable only of photographing events that are not self-luminous. With this type of event—a projectile in flight, for example—the exposure time can be controlled by the duration of the light source. One convenient light source is an electronic flash tube. Most of the work on such flash tubes has been done by Harold Edgerton of Massachusetts Institute of Technology. Edgerton's latest type will give a flash with a duration as short as 1 microsecond (10^{-6} second) and an effective brightness of 1 million candlepower (*2*). We have used this lamp with an Edgerton, Germeshausen, and Grier stroboscope to obtain multiple-exposure pictures with a Land camera to give immediate data on the velocity of fast-moving objects.

Another light source frequently used in high-speed photography is a spark gap. By proper design, the effective duration of light from a spark gap can be made considerably less than 0.1 microsecond.

A multiframe camera using spark-gap illumination has been described by Fayolle and Naslin (*3*). This camera has a framing rate in excess of 1 million frames per second for a total of 30 frames and is especially useful for schlieren photography. It uses an optical arrangement first proposed by Cranz and Schardin in 1929 (*4*). Figure 1 shows schematic diagrams of the camera. Essentially it consists of 30 cameras which have either a common objective lens or a common concave mirror in their optical system. Each individual lens can see the object only when the particular spark gap focused on it is fired. The framing rate of this camera is controlled by the firing rate of the spark gaps.

Figure 2 shows a series of schlieren pictures of a bullet emerging from a gun barrel, taken with an 18-frame version of the camera. The schlieren technique shows density variations in a gas due to changes in the refractive index of the gas with density. A concave mirror focuses the image of a point source of light on a knife edge which partially intercepts the image. Schlieren photography is used extensively for wind-tunnel studies of models of supersonic missiles and aircraft. In Figure 2, the bullet (seen in outline only) is traveling in a cloud of propellant gas from the muzzle of the gun. By frame No. 13 the bullet has outrun the gas cloud and is making a shock-wave pattern in the undisturbed air.

Recently the cathode-ray tube has been used as a light source, since the tubes that have been developed for projection of television pictures have very high spot intensity and can be supplied with a phosphor having a decay time of only 0.2 to 0.3 microsecond (*5*).

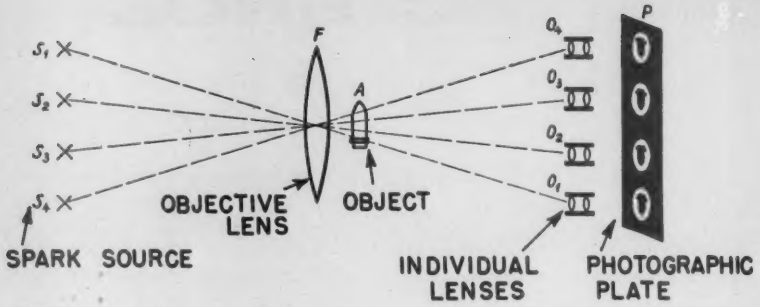
J. S. Courtney-Pratt has described a high-speed micrographic camera with the same general design as that of Fayolle and Naslin. A multisided pyramidal mirror placed close to a microscope objective viewing the subject can be used to reflect images of the subject to a photographic plate.

Each face of the pyramidal mirror can be selected by a different position of the light spot illuminating the subject. An elegant combination can be made by using a cathode-ray tube as the light source, since the whole photographic process can be controlled by electronic circuits capable of deflecting the electron beam in the tube and turning it on and off. For very fast exposures, multiple spark gaps must be used in place of the cathode-ray tube in order to have sufficient light intensity (*6*).

The micrographic camera just described can be easily modified to permit the study of luminous events by the addition of a rotating shutter (*7*).

If a secondary explosive charge can be tolerated in the experiment, an ex-

The author is affiliated with Arthur D. Little, Inc., Cambridge, Mass.



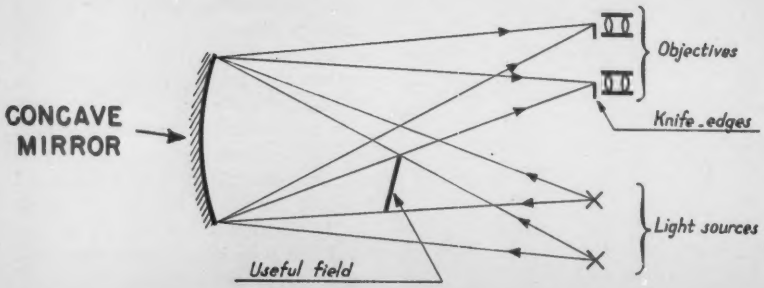


Fig. 1. (Left, top) Simplified schematic diagram of Cranz-Schardin camera. (Left, bottom) Cranz-Schardin camera used for schlieren photography. [From P. Fayolle and P. Naslin, "Simple electronic devices for high-speed photography and cinematography," in *Journal of the Society of Motion Picture and Television Engineers* **60**, 603–626 (1953), and Reprint Volume 5, *High-Speed Photography* (Society of Motion Picture and Television Engineers, 1954), pp. 101–124; courtesy Society of Motion Picture and Television Engineers]
Fig. 2. (Below) Schlieren photograph of a bullet just after it leaves the gun barrel. The framing sequence runs from left to right and from bottom to top. Note the change in parallax from frame to frame. [Courtesy P. Naslin, Laboratoire Central de l'Armement, Paris, France]

tremely intense flash can be obtained from an argon flash charge. When the shock wave from a *brisant* explosive (an explosive having high detonation velocity and power) passes through argon gas near the explosive, a light flash is produced which lasts as long as the shock wave is in the argon. By proper control of the shape and thickness of the argon layer and the shape of the detonation wave in the explosive, the duration of the light pulse can be controlled. Since the shock wave from a *brisant* explosive travels at a high velocity (8 mm/μsec), it is possible to get a flash of very short duration. Bagley has described a small argon flash that can be used in the laboratory with an effective duration of 10^{-8} second (*8*).

On the other hand, if the shock wave can travel a long distance through argon, a "long-peak" flash with a duration of several hundred microseconds can be produced to provide illumination for cameras that use some other method of control of exposure time. At Arthur D. Little we have used a rubber balloon several feet in diameter filled with argon as a long-duration light source. The explosive charge, weighing about ½ to 1 pound, is taped to the side of the balloon away from the event to be studied. The peak brilliance of the argon flash is about 5 to 7 million candlepower per square centimeter (*9*).

Another light source that can be used to provide light of relatively long duration is an exploding wire. A fine silver or copper wire (BS No. 36 to No. 40) will produce a bright flash about 50 to 60 microseconds long when a condenser of 1 microfarad charged to 15,000 volts is discharged through it. The duration and brightness of the flash can be increased by increasing the voltage rating and capacity of the condenser. I have used as much as 4 microfarads and 30 kilovolts, but the cost and volume of the larger condenser bank are such that the results obtained do not justify its use.

Image Compensation

A number of camera types have been described that are not limited to nonluminous subjects. The most widely used type of high-speed camera is actually first cousin to the moving-picture camera. In a moving-picture camera the film moves one frame, the shutter opens and closes, and the film moves again. This type of movement will work up to about 400 frames per second. At a higher framing speed, the film tears because of the high acceleration required. Figure 3 shows a simplified schematic diagram of an "image-compensation" type of high-speed camera which is available in several commercial models. In this type of camera the film moves continuously from the feed spool to the take-up spool. The shuttering action is provided by a glass prism (a

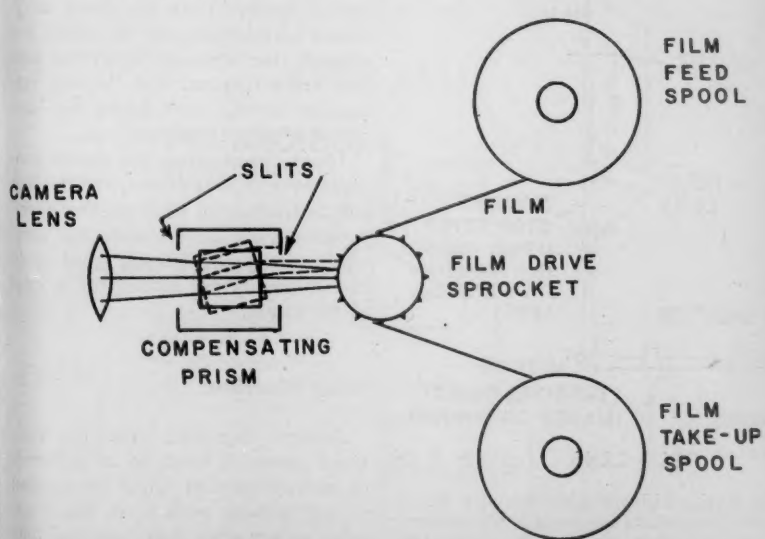


Fig. 3. Schematic diagram of a rotating prism image compensation camera.

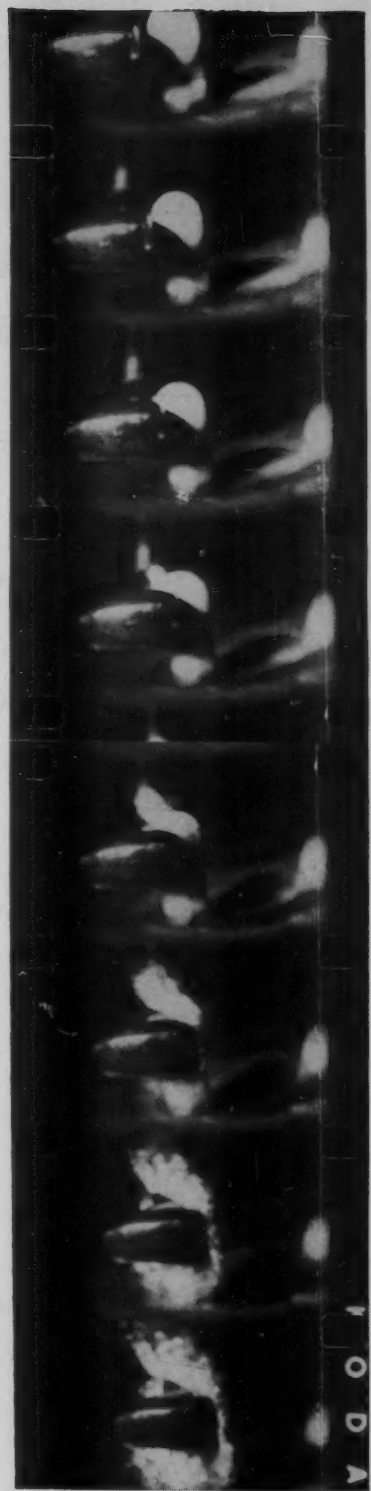
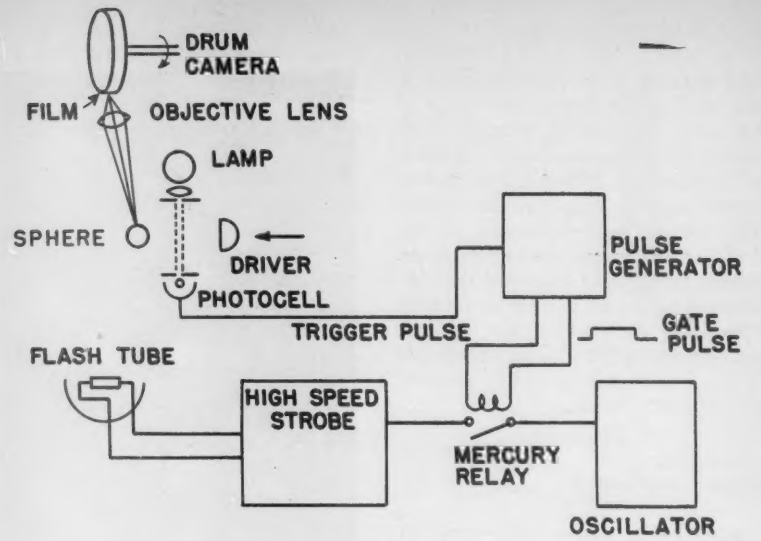
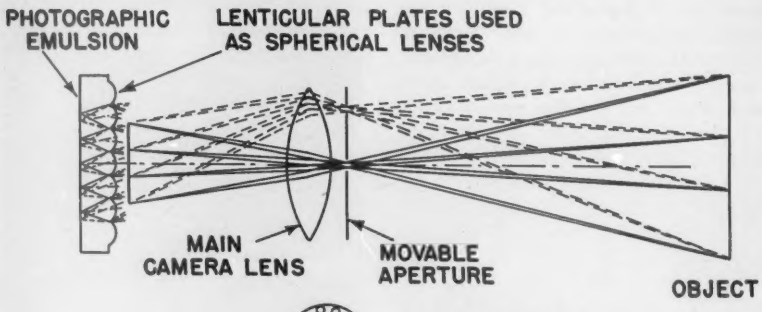


Fig. 4. Club breaking an egg. Framing rate, 6500 frames per second; effective exposure time, 1 microsecond.





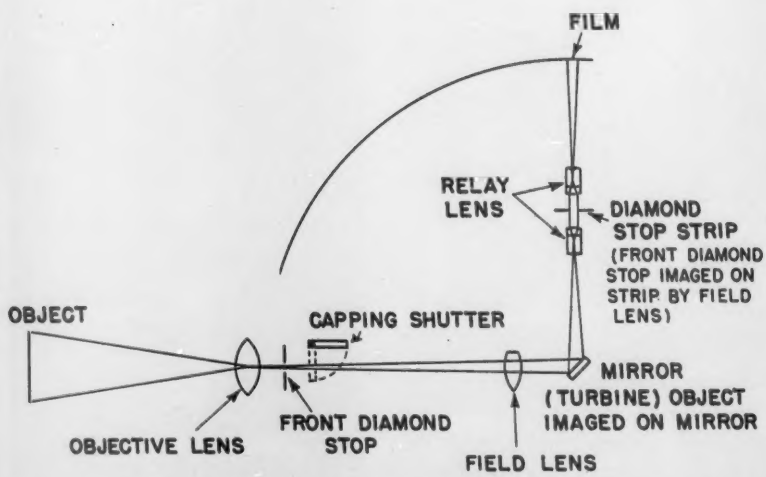


Fig. 5. (Top) Schematic diagram of setup for making high-speed pictures of a driven sphere. Fig. 6. (Middle) Optical system of the image-dissection camera of J. S. Courtney-Pratt. Fig. 7. (Bottom) Schematic diagram of the optical system of the model 189 framing camera. [Beckman and Whitley, Inc.]

cube in this case) geared to the film drive sprocket. By proper choice of prism and gearing, the movement of the image resulting from the refractive effect of the prism can be approximately matched to the movement of the film for about a 20-degree movement of the prism. Shuttering action is provided by slits on either side of the prism. The maximum framing speed of a camera of this type is determined by the bursting strength of the glass prism, the maximum speed at which the film can be driven, and the frame height chosen. The maximum framing rate for a 16-millimeter frame height would be 7500 frames per second, with an exposure time of 30 microseconds per frame. Halving the frame height doubles the speed.

We have done some research on the measurement of the dynamic compressibility of elastic spheres. During this program we made a number of high-speed moving pictures of spheres as they were hit by fast-moving objects. In our early tests we used a Fastax image-compensation camera with the addition of an Edgerton, Germeshausen, and Grier high-speed stroboscopic-flash unit synchronized with the Fastax to shorten the effective exposure time to about 1 microsecond. Figure 4 shows the result when an egg was used while we were testing the apparatus.

For a later series of tests we used an arrangement that gave us much sharper pictures. This arrangement is shown in Fig. 5. Instead of a Fastax we used a rotating drum camera. The framing rate was controlled by the flashing rate of the stroboscope. The stroboscope started flashing when the driver intercepted a light beam near the sphere and stopped after a period slightly less than one drum rotation. The flashing rate was set so that each frame was separated from the preceding one.

Image compensation can also be provided by a rotating mirror, and the film can be transported on a rotating drum. A commercial camera uses this combination to give a framing speed up to 25,000 frames per second for a total of 96 frames.

Image Dissection

Another ingenious type of high-speed camera is based on the principle of image dissection. Close observation of the halftone pictures in this magazine, or any other, will show that they are actually made up of tiny dots, reg-

Fig. 8. Air drag measurements in a shock tube. Part of a frame from a series taken by a Beckman and Whitley Model 192 framing camera. The objects (one cone and a sphere) are in free flight at Mach 10.5. Note the shock waves around each object. [Courtesy Gas Dynamics Division, Naval Ordnance Laboratory, White Oak, Md.]

ularly spaced, the darkness of an object being determined by the size of the dots. This suggests the possibility that more than one image could be put on a single photographic plate if dot patterns were placed side by side, since the eye can see a pattern of dots as a picture. Figure 6 shows a diagram of such a camera now commercially available. The image of the object to be photographed is focused by the main camera lens on a special lenticular plate. This plate, made by a firm in Paris, effectively dissects an image falling on it into a series of dots, the position of the dots depending on the direction from which the light falling on the plate is coming. The dots can be spaced as close as 25 dots per centimeter, and the effective diameter of each dot can be made less than 0.02 millimeter (*10*).

The direction of the light in the image falling on the lenticular plate (Fig. 6) is determined by the movable aperture which rotates just in front of the camera lens. In this way, 200 images, each one containing 90,000 dots, can be put on a single photographic plate. The scrambled image can be unscrambled again when the processed plate is put back in the camera with the light behind it, and the camera is used as an enlarger to project each image as the aperture is moved. This camera can take a series of pictures at framing rates as high as 200,000 frames per second.

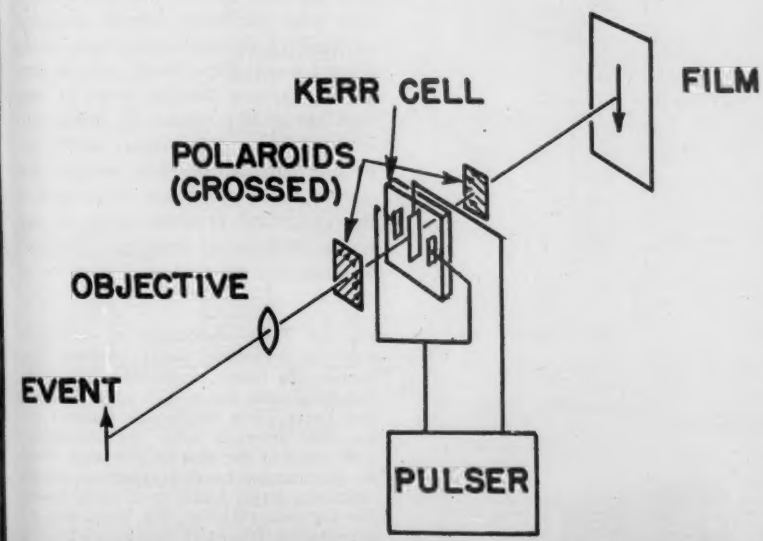


Fig. 9. Schematic diagram of a single exposure Kerr cell camera. Minimum attainable exposure, 5×10^{-9} second.

Framing Camera

Another type of multiple-frame camera that uses mechanical means to achieve very short exposure times is the so-called "framing camera." Designed during World War II for research on explosives, the camera has been improved by a group at Los Alamos under B. Brixner (*11*). Several models of this camera are now in commercial production. As shown schematically in Fig. 7, the object to be photographed is imaged on a very-high-speed rotating mirror (up to 23,000 rev/sec) by an objective and a front field lens. The image on the mirror is then re-imaged on film through a second set of relay lenses. The shuttering action in this camera is provided by the two diamond stops. A fast capping shutter used in this camera consists of an optically flat glass block in the optical system of the camera. A detonator touching one side of the block shatters the block when it is fired, reducing the light sufficiently to prevent fogging of the film until a regular mechanical shutter closes. One model of this camera, built at Los Alamos, has a maximum framing speed of 15×10^6 frames per second for a total of 96 frames. A commercial model of the camera is continuously "open" (that is, it requires no synchronization of the event with the mirror position), costs $80,000, and has recently been advertised as "*the* instrument for the laboratory that has everything."

Figure 8 is part of a frame of a series of pictures taken at the Naval Ordnance Laboratory with a framing camera. In this case, the camera was

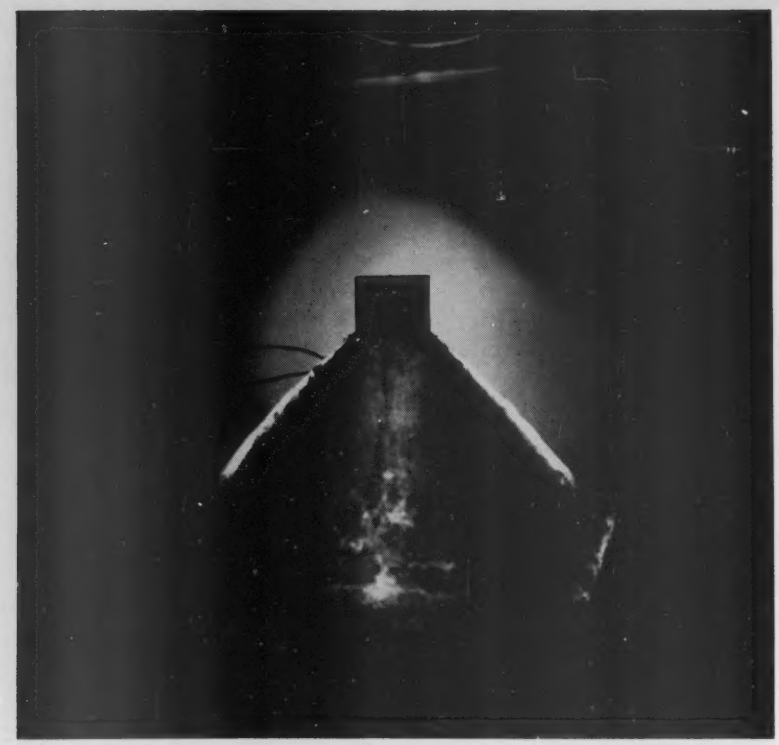


Fig. 10. Detonation of a stick of high explosive. A 35-millimicrosecond Kerr cell shutter photograph of a detonating ¾-inch-square stick of composition B (a military high explosive) that was detonated at the rate of 7.8 millimeters per microsecond. A combination of argon flash front lighting and exploding wire bacz lighting was used. [Courtesy Detonation Physics Branch, Ballistic Research Laboratories, Aberdeen, Md.]

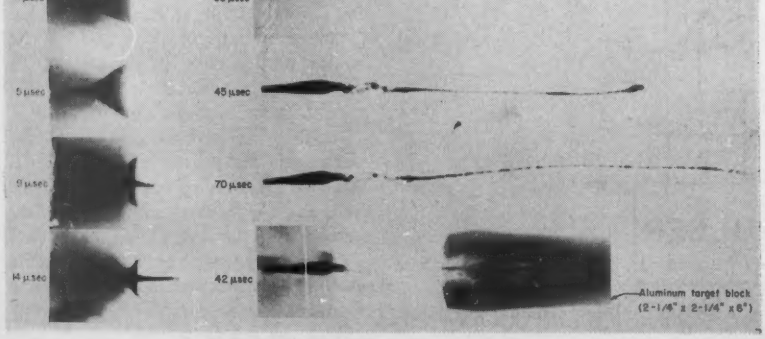


Fig. 11. Flash radiograph of collapsing liners in detonating cavity changes. The liner is 1⅝ inches in diameter and 0.032 inch thick and has a 42° internal angle. The times given beside the pictures are the time intervals after the detonation front reached the base of the cone. Note the considerable internal expansion of the aluminum target block in the last frame. The exposure time for each frame was 0.1 microsecond. [Courtesy Detonation Physics Branch, Ballistic Research Laboratories, Aberdeen, Md.]

used to obtain drag and stability data at very high Mach numbers (Mach 10.5). The objects to be studied were suspended in a shock tube with fine wires, and the flash tube used for lighting was flashed as the shock wave reached them. The duration of the light was electrically controlled to prevent double exposure. A shock tube is a device for obtaining very high pressure pulses and very high gas velocities in the laboratory. High-pressure gas in a chamber is confined by a diaphragm which releases the gas into a connecting tube; a shock wave runs down this tube and can be used in any way desired. The actual drag measurements were obtained from a plot of the position and attitude of the objects under study from frame to frame.

Another type of very fast capping shutter has been described by Edgerton (*12*). A lead grid between two glass plates is fused by a condenser discharge. An optical density of 3 can be produced in about 30 microseconds with this method.

Streak Camera

A specialized camera useful for measuring velocity is the "streak camera." The image of a slit is swept continuously along a strip of film. The resulting picture is a plot of the position of a phenomenon along the slit as a function of time. Although the results obtained are sometimes hard to interpret, a streak camera will give reasonable time resolution without requiring extremely high rotational speeds in the camera mechanism. Streak cameras employing mirrors that do rotate at very high speeds are subject to image distortion due to deformation of the reflecting surface. In some designs the stresses in the mirror are 80 percent of the theoretical breaking stress at top speeds. Brixner has described a method of measuring the surface distortions of

the mirror as it rotates so that correcting lenses can be made to compensate for this distortion at several speed increments (*13*).

Shutters

There are two types of fast shutters based on the effect of an electric or magnetic field on the rotation of polarized light passing through a substance. The Kerr cell uses the birefringent liquid nitrobenzene as a shutter. Figure 9 is a schematic diagram of a Kerr cell. A glass cell containing nitrobenzene is placed between crossed Polaroids. When a very strong electrical field is induced between the plates in the cell, the plane of polarization changes and the shutter opens. The open time of the shutter is controlled by the length of the pulse applied to the plates and can be made as short as 5×10^{-9} second (*14*). Figure 10 shows a picture of a stick of detonating explosive taken with a Kerr cell camera at the Ballistic Research Laboratory.

Edgerton (*15*) has used the Faraday effect to make a fast shutter. Like the Kerr cell, the plane of polarization in dense flint glass is rotated by a magnetic field. Due to the inductance of the coil producing the magnetic field, the minimum exposure time of this shutter is about 1 microsecond.

One other type of electrical shutter in use today is based on the "snooperscope" used in World War II. An image converter tube in the snooperscope was used to convert infrared to visible radiation to allow observation of the enemy at night by infrared light. These tubes can be gated on and off by a pulse applied to a grid, and the image can be deflected by a magnetic coil around the tube. Certain types of image converters designed specifically for high-speed photography have been used to give exposure times as short as 1×10^{-9} second (*16*). With the addition of a magnetic deflection system the image converter can be used for multiple-frame photography or as a very fast streak camera (*17*).

X-ray Pictures

High-speed x-ray pictures have been extensively used for the study of explosions where the event of interest is hidden by the reaction products of the explosive. Of course, the x-ray picture is a shadowgraph produced by the illumination from a point source and is limited in resolution by the size of the point source.

Figure 11 shows a series of flash x-ray photographs of the collapse of a cone in a shaped charge, taken at the Ballistic Research Laboratory. The shaped charge was first used in military weapons during World War II, to increase the penetrating power of an explosive warhead when used against armor or reinforced concrete. The shaped charge consists of a hollow metal cone set in the end of a block of explosive. When the block is initiated at the end opposite to the cone, the cone collapses and squirts out a jet of metal traveling about 8 kilometers per second that will make a pencil-sized hole through a thickness of steel about 5 times the cone diameter.

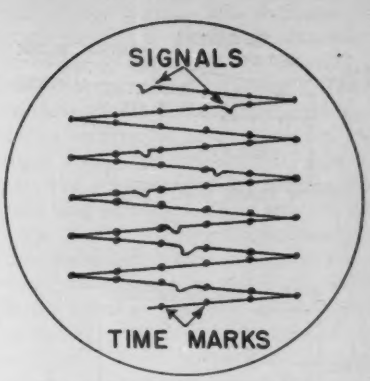


Fig. 13. Oscilloscope trace.

Since the transmission of x-rays through a substance depends on the density of the substance, it is possible to measure the effective density of a compressible substance under dynamic conditions with high-speed x-ray photographs. If density and shock velocity in a material can be measured, the compressibility of an explosively pressurized material can be calculated for a pressure range of 10^4 to 3×10^5 atmospheres (*18*).

Velocity Measurements

The conductivity due to ionization in the detonation zone of an explosive approaches that of a metal. The pressure and temperature involved in the zone are also sufficient to break down insulating materials. This high conductivity can be used to make very accurate measurements of detonation velocity, since a pair of wires through the explosive will be shorted together by the detonation front. Figure 12 is a schematic diagram of an apparatus that we use on a routine basis to obtain detonation velocities. The electronic circuits generate a crystal-controlled triangular sweep on the oscilloscope

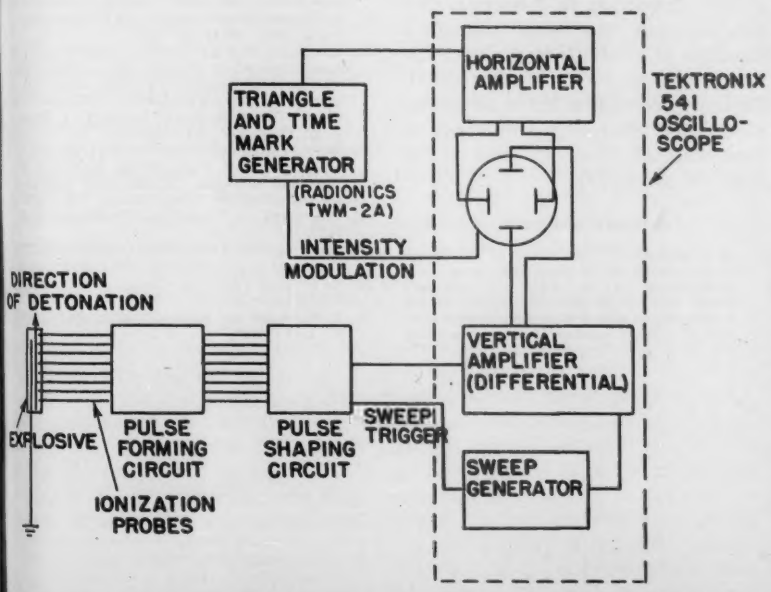


Fig. 12. Portable system for accurate measurement of detonation velocities.

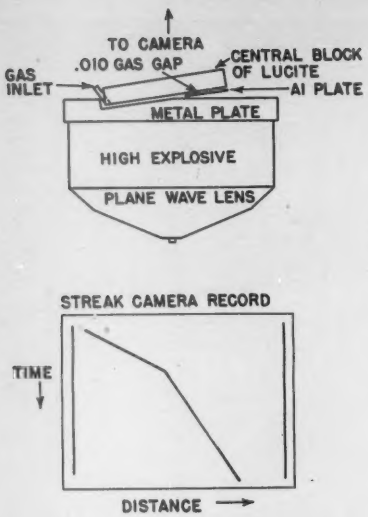


Fig. 14. Experimental setup for measurement of free surface velocity and shock velocity. [From J. M. Walsh and R. H. Christian, "Equation of state of metals from shock wave measurements" (*24*); courtesy the *Physical Review*]

(Fig. 13), with time marks visible as intensity modulation. As each ionization probe is grounded, a pip appears in the trace. This method gives an effective trace length of about 10 feet, enabling us to read time with good accuracy.

It is difficult to generate a triangular sweep with a very fast period, because of the very-high-frequency response required to transmit the sharp ends of the triangle. One solution that has been used is to employ two oscilloscopes with saw-tooth sweeps and common input. One sweep is delayed sufficiently to allow any pip to occur at a point where it can be observed. (*19*).

A method of measuring detonation velocity continuously has been used by several experimenters. Since the conductivity of the detonation front is high, a detonation in a metal-cased charge appears like a piston in a wave guide. The position of the detonation front can be detected by the change in the electrical characteristics of the wave guide at microwave frequencies (*20*).

Physical Measurements

There is another method of obtaining pressure-volume relationships at very high pressures: measuring the internal shock velocity and the free surface velocity of a substance in contact with a block of high explosive initiated in such a way that the detonation front in the block is accurately plane. These shock-velocity measurements have been made in two ways, electronically and optically. The electronic method uses pins set inside the sample and at known distances above it. These pins are short-circuited by the shock wave in the material and by the movement of the free surface (*21*), (*22*).

One optical method is shown in Fig. 14. The position of the internal shock wave and the movement of the free surface are shown by the light from a thin layer of argon behind a lucite block. The shock wave from the metal plate, and from the aluminum plate when it is struck by the metal plate, makes a visible flash in the argon that is recorded by the streak camera.

The break in the streak-camera trace marks the change from the faster shock velocity to the slower free-surface velocity (*22*).

Explosives have been used to induce metallic transitions in insulators. Certain materials like iodine undergo a transition to a metallic state with a low energy requirement (5 electron volts). Explosive pressures of 2.5×10^5 atmospheres have changed the resistivity of these materials from 10^8 ohms to less than 100 ohms (*23*).

References and Notes

1. It is impossible in an article of this length to give credit to all those who have made contributions to the study of high-speed events. The reader who has further interest in the subject will find that the works cited lead to a large number of other references.

2. H. E. Edgerton, "Small zenon flash tube," *Proceedings 3rd Conference on High Speed Photography* (Butterworth, London, 1957), p. 51.
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Modern Instruments for Surveying and Mapping

New surveying systems utilizing photogrammetry and electronics speed production of topographic maps.

George D. Whitmore, Morris M. Thompson, Julius L. Speert

Reliable topographic maps are the indispensable medium for planning and directing many kinds of modern scientific and engineering operations. The ever-growing need for such maps has mothered the invention of new and remarkable devices that in a relatively short time have relegated many of yesterday's surveying instruments to the museum shelf.

Until a few decades ago, the topographer (the man who made topographic maps) was a combination of engineer and artist-craftsman. He knew how to make engineering measurements with the classical surveying instruments of the time—the theodolite, the steel tape, the spirit level, the alidade, and the plane table. He also had the necessary talent for filling in map detail by on-the-spot observation and for interpretation of the terrain in relation to measured points—a talent that was partly scientific and partly artistic. The topographer rode or tramped or waded over the length and breadth of the area assigned to him. He originally relied entirely on horses for local transportation but later used the automobile to the extent feasible. With a few temporary field assistants, he did the job from beginning to end, and the resulting topographic map bore his imprint as surely as a painting bears in its composition the signature of the artist.

Although there are still many field tasks that require the services of surveyors and engineers, the field men of today are responsible for only limited portions of the mapping operation, which in large part are accomplished with new kinds of surveying instruments and transportation equipment. Nowadays, more than half of the surveying operations, particularly those entailing the actual drawing of map detail, are likely to be performed in a modern air-conditioned office by city-dwelling specialists using ingenious new instruments, far removed from the mountains and fields and woods being surveyed.

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Photogrammetric Instruments

The most important factor in the development of modern topographic survey practices is, by all odds, the use of aerial photographs and the application of the science of photogrammetry (obtaining reliable measurements by means of photography) (*1*).

The aerial photograph is now a familiar working tool in many scientific disciplines besides topographic mapping. The geologist, forester, agronomist, or any other scientist dealing with the character of the earth's surface must be familiar with the advantages and limitations of aerial photographs if he is to consider himself knowledgeable in his profession. The great impetus to the use of aerial photographs, however, resulted from the needs of the topographic engineer, and it was in the course of meeting these needs that modern photogrammetric instrumentation was developed.

To understand the problems of photogrammetry, it is necessary to recognize at the start that an aerial photograph does not, in itself, constitute a map (see Fig. 1). Because of variations in ground elevations, tilting of the aerial camera, lens and film aberrations, and other phenomena, the aerial photograph usually gives a distorted picture of the terrain. Furthermore, a single aerial photograph affords no means of measuring variations in the height of the terrain. For converting the information contained in the aerial photographs into accurate topographic maps equivalent to those based on conventional ground surveys, various plotting instruments have been developed. These instruments range from relatively simple devices, used for the production of maps of relatively low precision, to elaborate stereoscopic plotting machines designed for producing maps of a high standard of accuracy. These instruments are, in general, increasingly more complex as a higher degree of precision is attained.

Although there are wide differences in the mechanical details and in the degree of accuracy attained, practically all stereoscopic mapping instruments operate on the same principle (see Fig. 2). A pair of photographs taken at successive exposure stations and overlapping by about 60 percent are oriented in the instrument to recover their relative orientation at the instant of exposure. By means of a carefully calibrated projection system, each photograph is projected through a perspective center so that the angular relationships at that point are identical with those at the exposure station when the photograph was taken. A stereoscopic viewing system is provided so that a miniature model of the terrain appears to be created. The model can be brought to the desired scale and oriented with respect to both a horizontal and a vertical datum, as represented by ground-survey control points. Measurements are made by means of a "floating mark" whose position with relation to the ground surface can be plotted orthographically on the map while the floating mark is moved "along the ground" of the "phantom model" to trace map detail. Since the space model is similar in every respect to the terrain in nature, the tilt and relief displacements are automatically eliminated.

Stereoscopic plotting instruments may be classified, according to their projection system, as follows:

In the optical-projection system transparent positive prints of the photographs (called diapositives) are projected through lenses so that the angular relationships of the emergent cone of rays duplicate those at the taking camera. In two well-known instruments of American manufacture, the ER-55 (Fig. 2) (Geological Survey successor to the multiplex aeroprojector) and the Kelsh

plotter (see Fig. 3), the images are projected directly on a tracing table platen at a finite distance and are viewed directly on the platen (*2*). In the German-made stereoplanigraph the projection is made through an objective at infinite focus, and the images are observed through an optical viewing system (*3*).

The mechanical-projection system utilizes space rods to carry out the projection. A space rod passes through a pivot corresponding to the perspective center of each photograph. The space rods can be made to move in any direction in space through this pivot point. When the instrument is properly oriented, and one end of each space rod is made to represent corresponding image points on the photograph, the intersection of the space rods represents the position of the point in nature. This principle is used notably in instruments of the autograph type (*4*), mainly of Swiss manufacture (see Fig. 4).

In the mechanical-optical-projection system the projection is made through a lens at the perspective center, but the connection with the measuring system is made through a mechanical linkage. Such a system is used notably in French instruments as well as in some of the earlier German ones (*5*).

The basic principles of these types of instruments were known and applied for many years prior to World War II; however, the continual improvement and refinement in mechanical, optical, and electrical elements have made the stereoscopic plotting instruments of today far superior in their capabilities to the pre-war models. Progress in this field is stimulated by a healthy rivalry among producers in Germany, Switzerland, France, Italy, Canada, Great Britain, the Soviet Union, and the United States; each of these countries has produced excellent instruments.

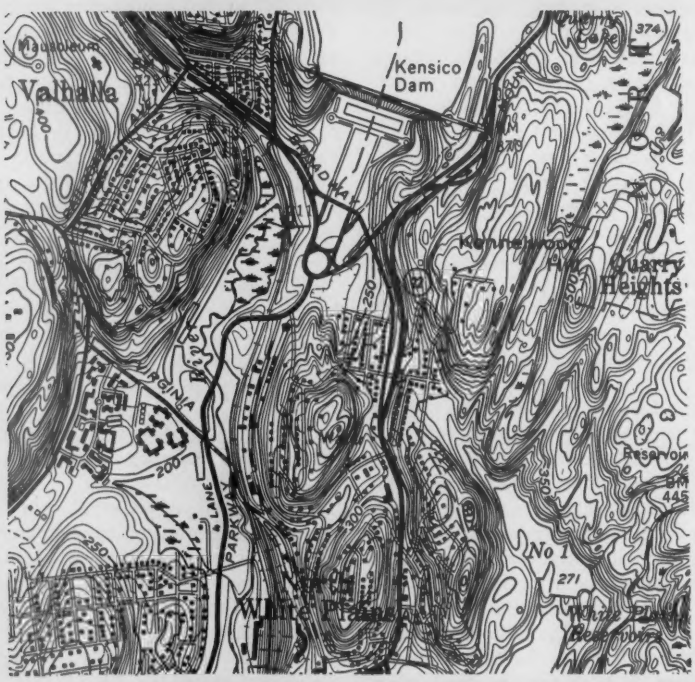


Fig. 1. Portion of an aerial photograph (top) used in the preparation of a topographic map (bottom). The map is a portion of the White Plains, N.Y., 7.5-minute quadrangle. Scale, 1:24,000. [U.S. Geological Survey]

Automation of Mapping Instruments

Currently, two major efforts in photogrammetric instrumentation are being made in the direction of automation. One of these efforts is aimed at automating the map-drawing operation itself. The other is aimed at utilizing modified mapping equipment in combination with electronic computing equipment to produce engineering data directly from the stereoscopic model without requiring a complete map as an intermediary.

The Stereomat

Automation of the map-drawing operation, while not yet practical for accurate topographic mapping, has been shown to be within the realm of possible attainment in the near future. A solid achievement in this field is the Canadian development originally known as "Auscor" (Automatic Scanning Correlator) and now called "Stereomat" (*6*). Further development of this apparatus has been undertaken by an American company.

The Stereomat (see Fig. 5) embodies a system of electronics and electromechanics which may be attached to a

conventional stereoscopic plotting instrument to perform the following functions automatically:

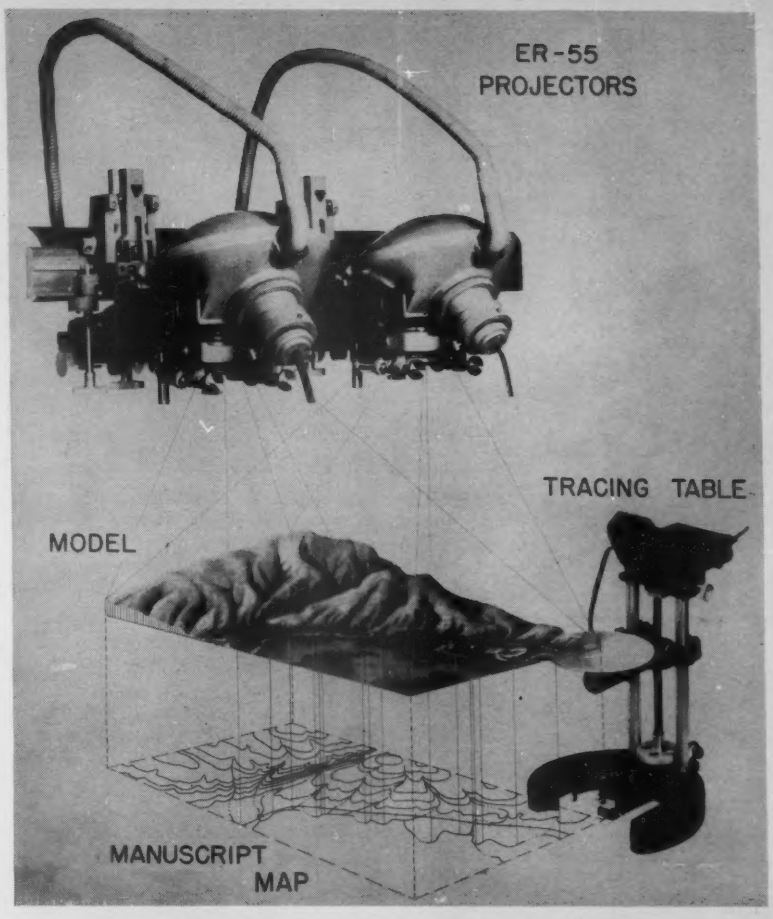
1) The system identifies corresponding points in the two photographs of the same object taken from different positions. This is accomplished by scanning the area around each point by a spot of light moving in a random pattern around and across the area being examined. The varying light impulses resulting from boundary crossings (between light and dark areas) in the photograph are converted to electrical signals by photomultiplier tubes. Associated electronic circuitry measures correlation of the electrical signals resulting from each photograph. The correlation is a measure of the common scanning area that is being searched. If the correlation is weak, the scanning pattern expands, and vice versa. Thus, points of image detail are identified by the pattern of surrounding images.

2) After identifying the images, the system determines the direction and magnitude of the parallax (failure of corresponding image rays to intersect) in both the X and Y directions separately. The circuitry thus produces two direct-current voltages, one for Y parallax and one for X parallax. The polarity of the voltages is dependent upon the direction of the parallax, and the magnitude is dependent upon the amount of parallax.

3) The X parallax error voltage is fed to a servo motor which actuates the elevation of the projection table. When the error voltage becomes zero, the servo motor stops and the index (floating) mark is on the terrain surface of the phantom model.

4) The Y parallax error voltage is automatically switched to appropriate servo motors which actuate the projection heads of the plotting instruments to remove Y parallax, thus completing relative orientation of the projectors.

5) In the contouring application, X parallax error voltage is combined with other information generated by the circuitry, to actuate X and Y servos which move the index mark in a horizontal plane in the direction necessary



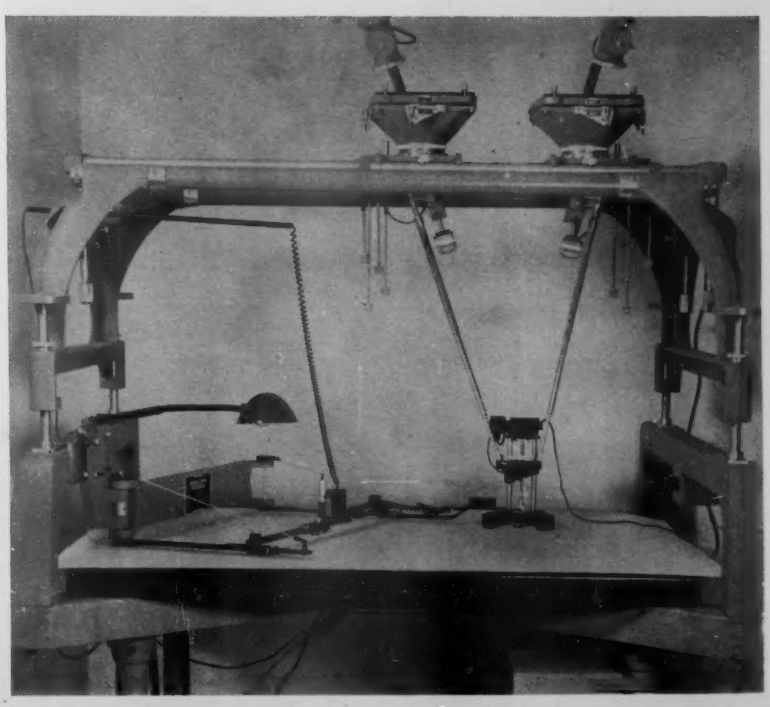


Fig. 2 (top). Mapping with a stereoscopic plotting instrument. [U.S. Geological Survey] Fig. 3 (bottom). The Kelsh plotter, an optical-projection mapping instrument with a direct anaglyphic viewing system (one photograph is projected in red, the other in blue; the observer wears corresponding spectacles with one red and one blue lens). [U.S. Geological Survey]

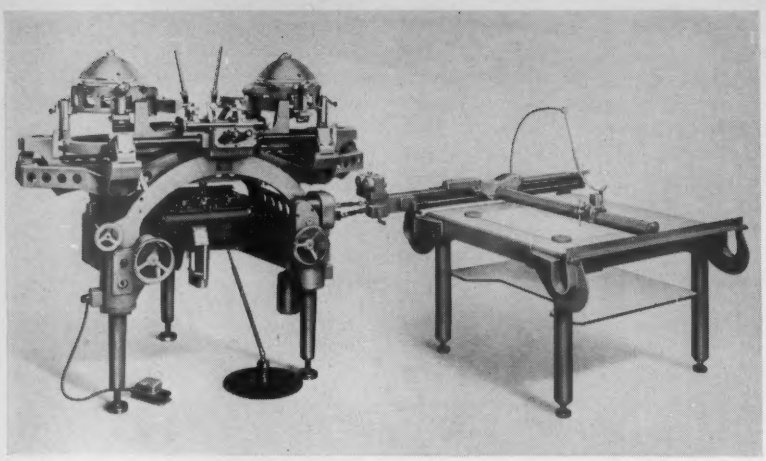


Fig. 4. The A-8 stereoplotter, one of the autograph series of instruments in which the projection is carried out by means of space rods. [Wild Heerbrugg Instruments, Inc.]

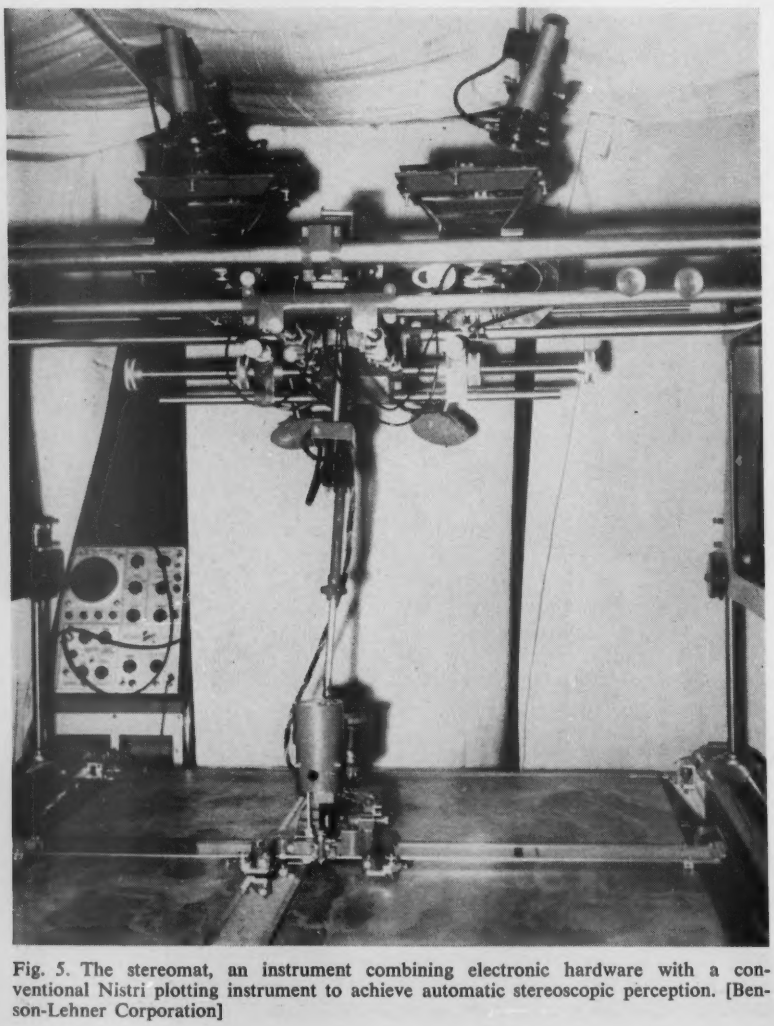


Fig. 5. The stereomat, an instrument combining electronic hardware with a conventional Nistri plotting instrument to achieve automatic stereoscopic perception. [Benson-Lehner Corporation]

to maintain the index mark "on the ground" at a given elevation. The index mark is thus steered automatically through the stereoscopic model so that its path is the locus of points of equal elevation, and a contour line is thus produced.

The Stereomat is a long way from being perfected, and the specialist who operates photogrammetric mapping equipment is in no current danger of being supplanted by a machine. Nevertheless, the indications are plain that automation will be a vital factor in the future of mapping instrumentation.

Automatic Engineering Computations

The nation's program of rapid expansion of the interstate highway system has placed a heavy burden of rather onerous computation on highway engineering staffs. For example, when a number of alternative routes are under consideration, an important factor in the selection is the relative amount of earthwork involved in the various alternatives. Earthwork computation by classical methods is a slow and costly process, completely out of tune with the urgency of the highway program.

The adaptation of photogrammetric mapping equipment to earthwork computation has helped to reduce this bottleneck in the highway program (see Fig. 6). In this adaptation, the tracing table of a conventional stereoscopic mapping instrument is hooked up to a read-out device which in turn feeds data to an electronic computer. Position and height readings of points on a highway cross section (or profile) in the stereoscopic model are fed to the computer, which is programmed to convert these readings to volume computations (*7*).

Orthophotoscope

Efforts are currently under way to apply similar automation to the Orthophotoscope (*8*), an instrument recently developed by the U.S. Geological Survey to produce something long desired by the engineer, the geologist, the forester, and many others—a uniform-scale photograph with no distortions due to tilt and relief. These orthophotographs combine the scale reliability of a map with the wealth of detail afforded by a photograph (see Fig. 7).

The Orthophotoscope (see Fig. 8) combines conventional stereoscopic

mapping equipment of the anaglyphic type (one image projected in blue, an overlapping image projected in red) with a means of exposing a sensitized film, bit by bit, through a narrow slit in a movable screen on which the model is projected. The elevation of the film is varied according to the terrain as the scanning proceeds. Tilt displacements are eliminated by proper orientation of the projectors. The sensitized surface is a blue-sensitive film which has no actinic response to the red light of the usual anaglyphic projection. The sensitized surface is thus differentially exposed by the projected blue image, always at the correct elevation to eliminate relief displacement. When the scanning is complete, the film is developed as a negative and the orthophotographs are printed from this negative in any quantity or on any scale.

The tedious part of the production of orthophotographs is the scanning operation, which requires that the operator continuously adjust the elevation of the film in order to keep the slit "on the ground" as the scanning proceeds. It is reasonable to expect that this height-adjustment operation can be made automatic by means of hardware similar to that used in the Stereomat.

Distance Measurement by Electromagnetic Waves

Although photogrammetric procedures are now the major means of making the detailed topographic survey, there remains the vital problem of providing suitable geodetic control (points of known position and elevation) to permit the map drawing to be related properly to horizontal and vertical datums. Such control is still obtained mainly by ground-survey methods, which are relatively high in cost. In some instances, the cost of ground-survey control has exceeded the cost of the photogrammetric operations. It is therefore only natural that intensive ef-

Fig. 6 (top). Hook-up of Kelsh plotter tracing table to read-out system for feeding data to an electronic computer for earthwork computation. [Aero Service Corporation] Fig. 7 (bottom). Corresponding portions of a perspective photograph (left) and an orthophotograph (right). In the perspective photograph the power line appears to be crooked, while in the orthophotograph it is shown in its true, straight alignment. [U.S. Geological Survey]

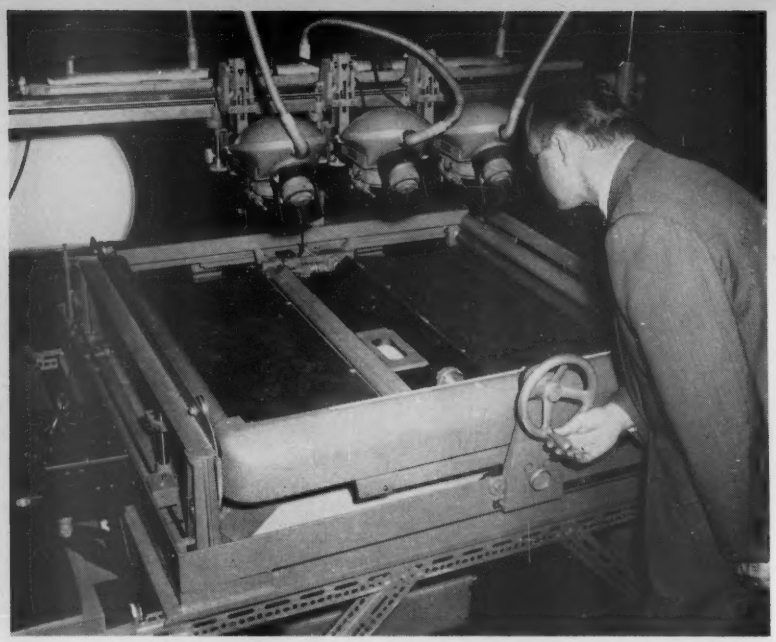


Fig. 8. The orthophotoscope, a combination of conventional ER-55 plotting equipment with a photo-scanning arrangement. [U.S. Geological Survey]

forts are being made to reduce the cost of this field work.

One of the critical problems in connection with field surveying is the problem of obtaining accurate and economical distance measurements for triangulation base lines and for traverse courses. As recently as a few years ago, the most reliable and economical method for accurate distance measurement in surveying work was the tedious procedure of direct measurement with a steel or invar tape. Much of this has been changed within the past few years by the introduction of new scientific instruments which exploit the modern techniques of electromagnetic wave transmission and electronics.

Geodimeter

The first successful development in this direction was the geodimeter, a system developed and manufactured in Sweden, in which a modulated light beam is directed from apparatus set up at one survey station to a reflector set up at a second station (*9*). The distance between the two stations is determined as a function of the phase relationships between the emitted beam and the reflected beam at various modulation frequencies and the precise value of the velocity of light. The system requires clear weather, darkness, and an unobstructed path between the two stations. Distances up to 30 miles have been measured with an accuracy good enough for geodetic base lines. The geodimeter also gives good results for short distances. It is not affected by moving or stationary objects in the vicinity of the stations or sight line.

Fig. 9. The tellurometer. Distance measurement with this instrument depends on the known velocity of radio waves. [U.S. Geological Survey]

Tellurometer

Soon after the introduction of the geodimeter, another valuable distance-measuring system, the tellurometer (see Fig. 9), became available (*10*). The principle of the tellurometer, developed and manufactured in South Africa, is essentially as follows: A modulated continuous-wave radio signal is transmitted from a master unit set up at one survey station; this signal is, in effect, received and retransmitted by a remote unit set up at the second survey station; the phase of the return signal is compared with the phase of the initial signal at several carefully selected modulation frequencies; these phase differences are read on the face of a cathode-ray tube and, through the relationship of the selected frequencies, are readily converted to transit time of the radio signal between the stations. The distance is derived as the product of the measured transit time and the known velocity of radio waves.

The tellurometer can be operated in daylight or darkness. It has the advantage of being able to penetrate haze, smoke, fog, clouds, and light rain; it will even penetrate a limited amount of foliage or timber if the obstruction is not located too near one of the stations. The optimum distance for tellurometer measurements is about 10 to 25 miles. Measurements up to 40 or more miles may be made under good conditions, although the accuracy falls off somewhat. Likewise, the accuracy falls off somewhat when the measured distance is less than 1 mile. The system is affected by reflections from nearby moving objects, such as waving grass or moving people or vehicles. Although some occasional "bugs" in the system are encountered,

experience to date with the tellurometer reported by the Geological Survey and other organizations indicates that the results are quite satisfactory.

The most recent development in this field, not yet in actual use, is an American system known as micro-dist (*11*). This system operates on the same basic principle as the tellurometer, although it differs in detail. In the micro-dist, readings are taken from a direct-reading counter instead of from a cathode-ray tube. Also, the master and remote units are interchangeable. Accurate measurement of relatively short distances is said to be possible.

Transportation and Communication

An integral part of the problem of making field measurements is the logistical problem of transporting men and equipment to the places where observations are to be made. The use of such modern vehicles as jeeps, "snocats," and helicopters (see Fig. 10) now enables the engineer to set up surveying equipment in swamps, in snow fields, on mountain-tops, and in other places that formerly could be reached only with difficulty, if at all. Communication is maintained by portable two-way radio.

Reconnaissance Systems

A number of other systems, mostly airborne, exploiting electronic and wave phenomena have been used successfully in reconnaissance mapping where the accuracy requirements are not so rigid. Some are described briefly below.

The radar altimeter (*12*) measures variations in the height of terrain, utilizing a radar beam emitted from an aircraft traveling at a constant pressure altitude.

Electronic tracking systems such as Shoran, Hiran, Raydist, and Decca can be used to determine the position of each aerial photograph exposure station with respect to two or more fixed ground stations or to keep the aircraft on a predetermined flight path. (By techniques of repeated measurement, such as are often used in geodetic ground surveying, Hiran has been used successfully for very precise measurement of lines too long for visual observation; distances as great as 500 miles have been measured this way.)

The Doppler system, entirely airborne, derives the speed of a photographic airplane from the frequency shift in a radar signal reflected from the ground and integrates this speed with respect to time, to obtain the distance traveled (*13*).

Radarscope photography (*14*) provides a means of obtaining survey data somewhat similar to poor-quality aerial

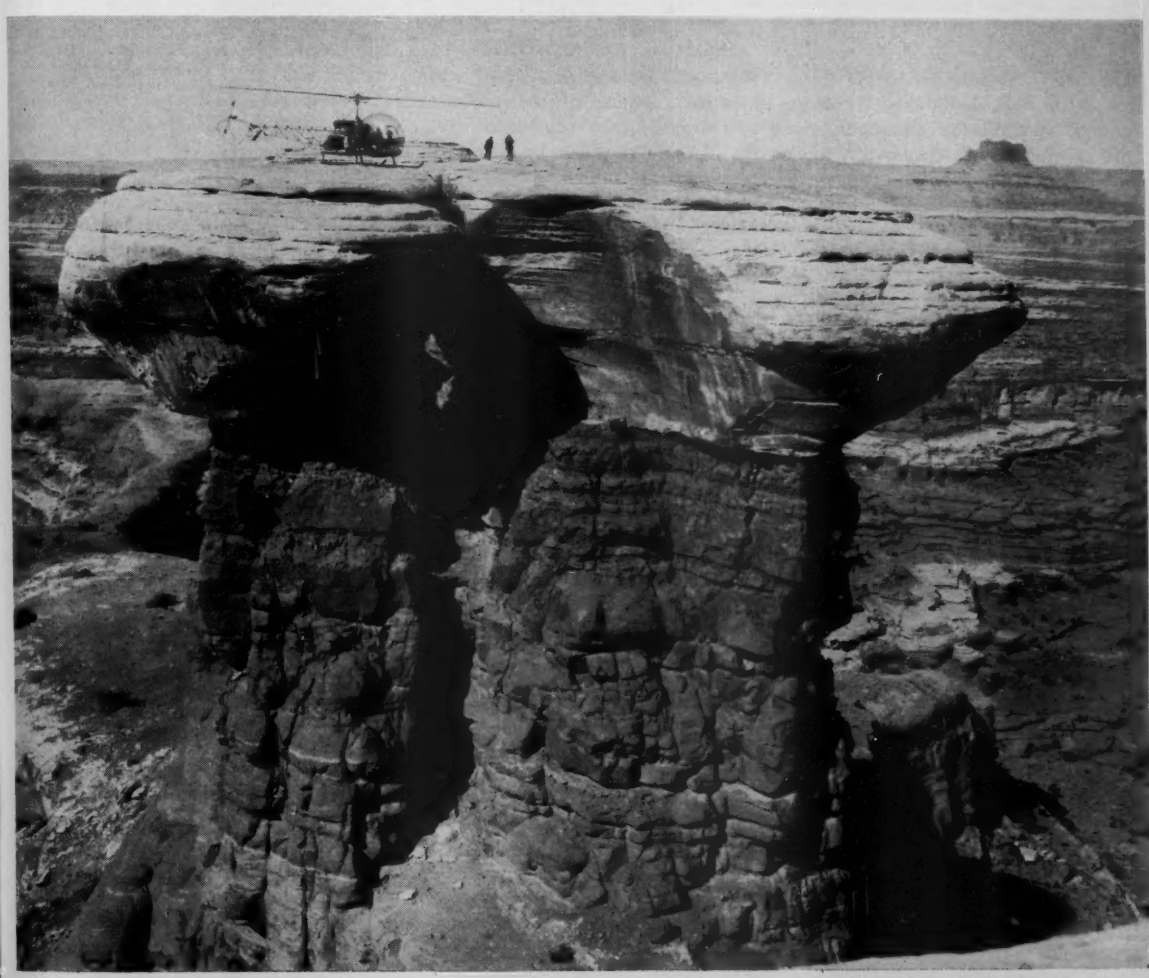


Fig. 10. The helicopter affords ready access to otherwise inaccessible survey stations. [U.S. Geological Survey]

Fig. 11. The elevation meter. In this system, functions of the angle of slope and the distance traveled are integrated electronically, as the vehicle proceeds, to give height differences. The slope function is derived from the action of an electromagnetic field on a sensitive pendulum. [U.S. Geological Survey]

photography, without requiring good weather or light conditions. Although the data that can be extracted from radar photography is deficient in some respects, it meets a vital need when normal sources fail.

Height Differences by Carborne Electronics

An interesting solution to the problem of providing vertical control (fourth-order elevations on a number of selected "picture points") for some types of mapping projects is offered by the elevation meter (see Fig. 11), a system developed in the United States (*15*).

The equipment is mounted in a four-wheel-drive carryall truck provided with four-wheel steering. As the apparatus proceeds along the road, an electromagnetic field acts on a very sensitive pendulum in such a way as to generate an electrical signal whose strength is proportional to the sine of the angle of slope. Another electrical signal is generated by a revolution counter connected to a special fifth wheel, which measures the distance traveled. By means of an electronic integrator, the two signals are combined into a continuous and automatic record of the difference of elevation from an initial starting point. To eliminate dynamic effects, the vehicle must be stopped to take elevation readings. Proceeding at moderate speeds over readily passable roads, the elevation meter can produce about 50 to 100 miles of leveling per day, reliable within about 2 feet, depending on operating techniques and distances between controlling bench marks. The elevation meter should be particularly economical on large projects where an adequate network of roads exists.

Conclusion

The engineer's mission is to put scientific knowledge to practical use. Modern surveying and mapping instrumentation affords an excellent example of the accomplishment of this mission. Many of the principles applied are based on very recent findings of modern science, with hardly a pause in the step from completion of basic research to useful application.

There are still plenty of scientific problems left to challenge the ingenuity of the surveying and mapping profession, however. Instruments and techniques are needed for establishing geodetic control without ground surveys, for mapping the ocean bottom, and for mapping the moon, other planets, and space. Some work is already being done in each of these directions. One can hardly doubt that the solutions will be found.

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The Brookhaven Medical Research Reactor

The first nuclear reactor designed specifically for medical research and therapy is described.

Lee E. Farr

A unique instrument, the medical research reactor, constitutes the heart of the equipment and machines of the new Medical Research Center of Brookhaven National Laboratory (Fig. 1). This is the only nuclear reactor which was conceived, designed, and built solely to add to knowledge of certain aspects of medicine. On 15 March 1959 this reactor became technically operative—that is, the core became "critical." While, since that time, the core has been operated at power levels up to 3 megawatts, it still must be described as only "technically operative," since a large battery of tests yet remain to be accomplished to establish the correctness of the design and materials used in the components surrounding the core, which are of prime importance in fulfilling the goals of this reactor design. In this regard, the core has been proved. The testing that remains is to determine the capacity of the instrument to deliver the neutrons or gamma fluxes at the point desired and in the purity required, without significant hazard to experimenters.

It is well at this point to define what is meant by a "medical research reactor." It is clear that at the present time all reactors which might be used in medicine are research in type. This reactor is therefore of a research type in this sense, but it is also "research" in two other senses. One is that ultimately, as an outgrowth of this experience, a true "medical reactor" may come to constitute one type of the presently growing family of nuclear reactors; the other is that for the immediate future, at least, it is a reactor the use of which will be limited to medical research. To encompass only the latter two senses, it is clear that two widely different reactor types may be used. The first is a general purpose or general research reactor wherein the primary usefulness for medicine is the generation of radioactive isotopes of medium term half-life. These radioactive isotopes can then be used for diagnosis, therapy, and studies in biochemistry, physiology, experimental pathology, and the like. In such a reactor no special medical devices are required, since the mechanical retrievers and access tubes are identical to those required for chemical, physics, or, in some instances, material-testing studies. It is clear that most biological fields can be served adequately by this type of reactor service.

Therefore, it seems advisable to reserve the term *medical reactor* or *medical research reactor* for those devices wherein the reactor itself is used for therapy or diagnosis or studies leading to therapeutic or diagnostic goals which have required characteristic and different design criteria for core or operation. Such special design criteria involve (i) shielding and moderation of neutron energies to provide the massive, externalized stream of neutrons or the separation of core emanations into relatively pure components as gamma or neutron emissions; (ii) the continuous supply, during a stated period, of very short half-life radioactive isotopes required by therapeutic maneuvers; and (iii) those purposes when the patterns or schemes of reactor operations are entirely dictated by the therapeutic or diagnostic trials involved. By this definition the new reactor at Brookhaven is indeed a medical reactor or medical research reactor. It is clear that many components of such a medical reactor will be found in general reactors and in the devices comprising a medical unit or accommodation at a general research reactor, but in such reactors there has occurred no significant alteration in core design or operational schema dictated by the use to which the reactor or its products may be put. It is to be expected that the number of medical units at general reactors (*1*) will outnumber medical reactors until studies with especially designed units such as the Brookhaven medical reactor have demonstrated a clear need for and superiority of one or more major features and some reasonably widespread specific diagnostic or therapeutic usefulness.

Description of the Reactor

The conception and criteria for operation of the new medical research reactor were the outgrowth of pioneering studies on neutron capture therapy (*2*) made possible by the great flexibility of the large, general-purpose graphite reactor at Brookhaven which became operational in 1951. Within a year thereafter, the desirability of a new design to meet specific medical needs was clear, and during 1952 the first of the engineering and design studies was undertaken which was to lead ultimately to the present reactor. Now a total of 8 years' experience with the Brookhaven graphite reactor has laid a foundation for further penetration into an unexplored region of medical-nuclear research utilizing the Brookhaven medical research reactor. This reactor is housed in a circular steel building 60 feet in diameter and 54 feet high (Fig. 2), which is connected to the main building complex of the Medical Research Center by two sets of air locks. One set provides entrance into the general area about the reactor, whereas the other set directly connects the radiation operating room with the reactor treatment room. The floor plan of these regions is shown in Fig. 3.

The reactor core is contained in a cylindrical aluminum tank 24 inches in diameter and 7 feet 7 inches high in the region of the core. The tank has an 8-inch pipe to lead cooling water in at

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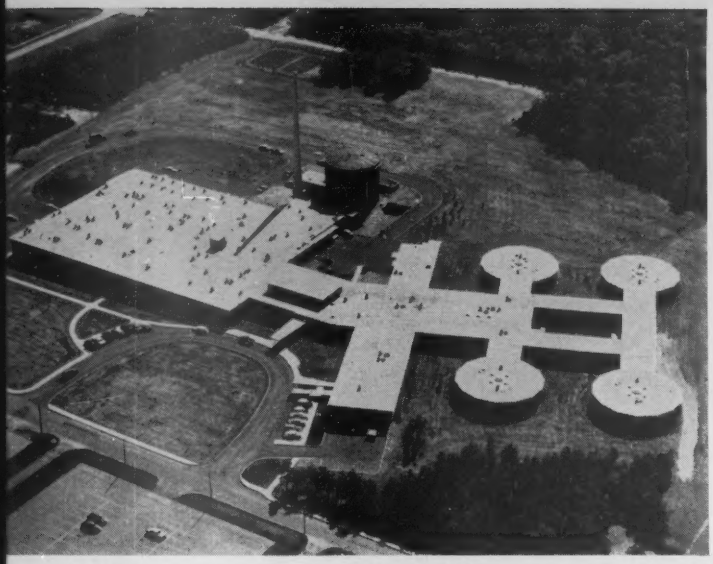


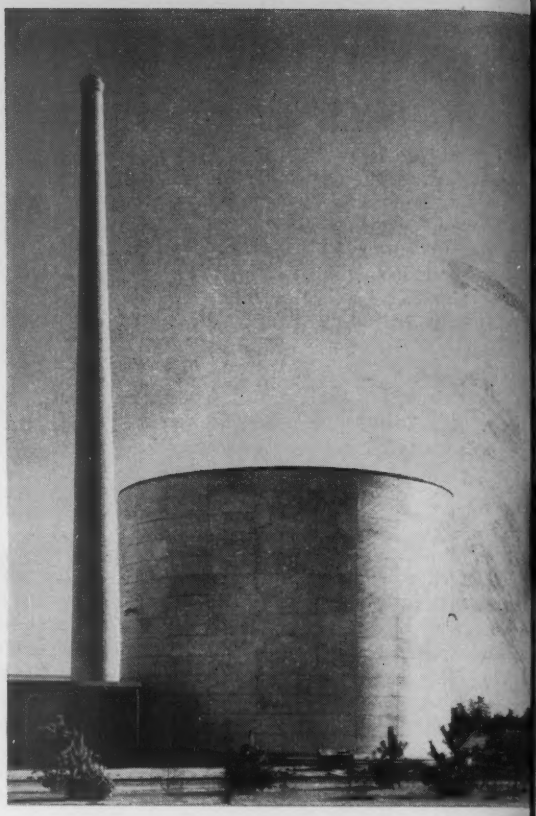
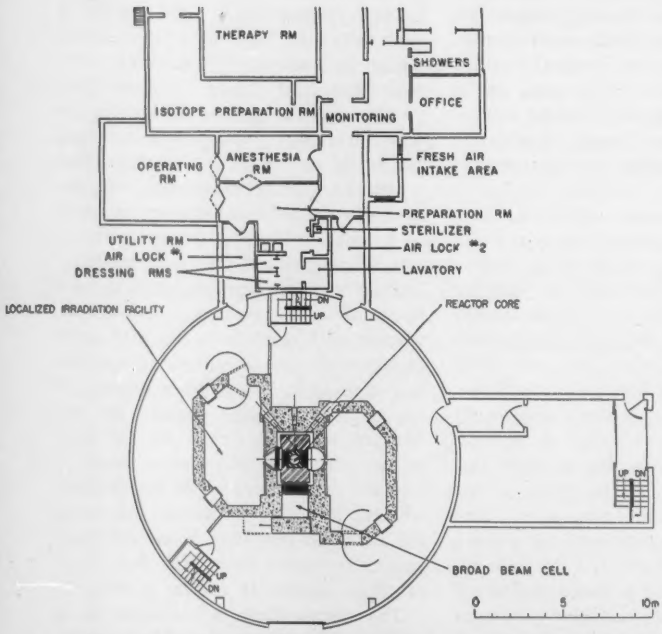


Fig. 1 (left). Aerial view of the Brookhaven Medical Research Center, showing the relation of the reactor building, top center, to the laboratory areas on the left and the hospital area on the right. The four circular buildings are the nursing units providing 48 beds, of which 40 are available for research patients. Fig. 2 (right). Reactor building and stack for discharge of cooling air from reflector of Brookhaven Medical Research Reactor.



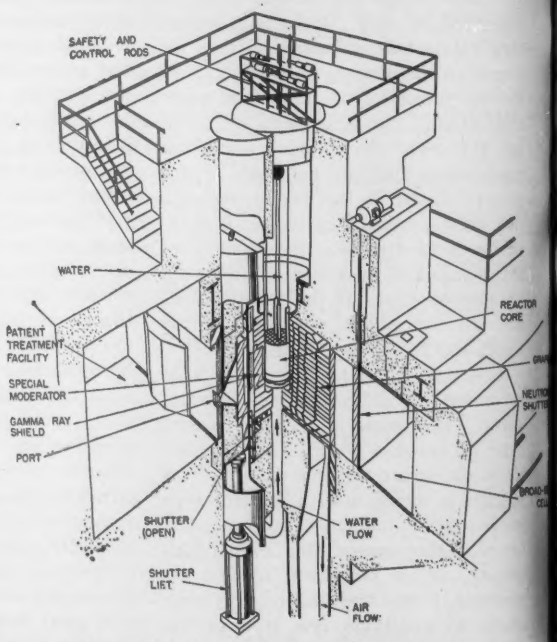


Fig. 3 (left). Floor plan sketch of Brookhaven Medical Research Reactor, showing the heavy shielding about treatment rooms and the adjacent operational and experimental units. Fig. 4 (right). Semidiagrammatic sketch of the Brookhaven Medical Research Reactor, showing general relations of its component parts. Instrumentation parts and units for specimen irradiation and activation are not shown. The 20-ton shutter can be opened and closed in 3 to 5 seconds.

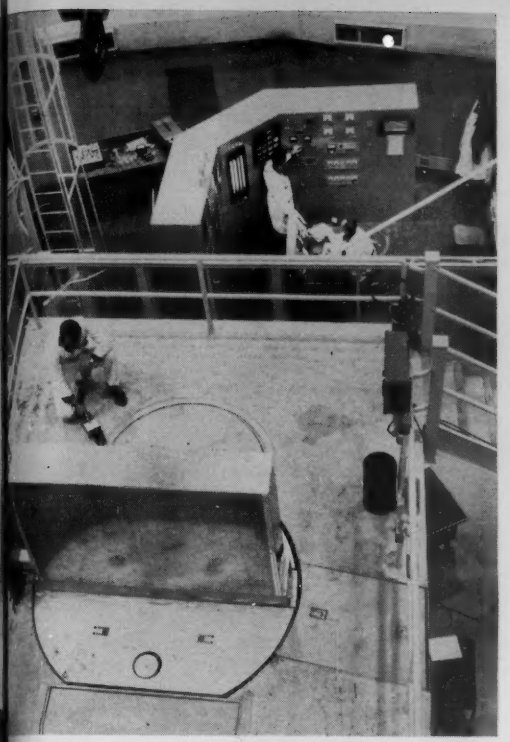


Fig. 5 (left). A view from above the Brookhaven Medical Research Reactor, showing the reactor control area on the mezzanine. Fig. 6 (right). A close-up of the control console of the Brookhaven Medical Research Reactor.

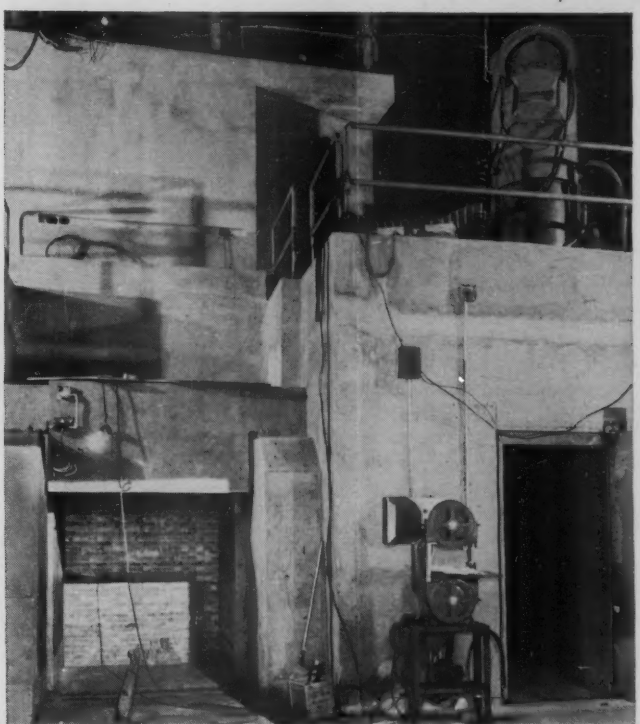


Fig. 7 (left). A view from beneath the Brookhaven Medical Research Reactor, showing the piping leading from pumps to the reactor tank. Fig. 8 (right). The broad-beam cell, showing the bare graphite reflector in the cell. Adacent is an entry door to an experimental room. This photograph was taken during construction.

the bottom. The tank is 60 inches in diameter and 12 feet high in the widened upper part, which thereby provides at the junction a circumferential shelf inside the tank which can be used as a temporary fuel storage area and as a decay tank. A schematic diagram is shown in Fig. 4. The reactor core is of the MTR (Materials Testing Reactor) general type, with BSF (Bulk Shielding Facility) type fuel elements. No experimental devices penetrate the core. With its configuration obtained with graphite reflectors about the core, a critical mass was produced with 2.249 kilograms of uranium-235 in 17, 140-gram fuel elements, each of 18 plates. The fuel is uranium-235 of over 90 percent enrichment, rolled into aluminum-clad plates.

Furthermore, the core design is such that, according to analyses made, the unit will not explode or vaporize in the event of instantaneous removal of all control rods. A dry, graphite reflector, approximately 3 feet thick, is placed around the core. The graphite reflector is cooled by filtered air that is blown through cooling passages provided. This exhaust air, and all air exhausted from the building, is passed through absolute-type filters and discharged from a stack 150 feet high. The core temperature is maintained by circulating natural water at 600 gallons per minute. To improve neutron economy the grid spaces about the fuel elements are filled with dummy units of graphite. All experimental channels through the shielding and graphite terminate in the graphite reactor. The operating conditions are controlled by three centrally located safety rods and one more peripherally placed regulating rod (Figs. 5 and 6). The control and regulating rod entrance tubes are located between fuel elements, rather than within fuel elements. This permits removal of fuel elements and reinsertion without disturbing the control rods. The water pumps, heat exchanger, and water treatment equipment are located in the basement of the reactor building (Fig. 7). The water treatment equipment is a standard, commercially available, mono-bed, ion-exchange column. The assumed duty cycle at present is 8 hours on and 16 off.

Since this reactor was designed specifically for use in the Brookhaven medical research program, it provides two shielded rooms, on either side of the reactor, primarily to further studies on neutron effects with particular reference to development of neutron capture therapy (*3*). Vertically moving shutters weighing 20 tons are provided to control neutron and other radiation emission through special ports into these rooms.

The construction differs on the four faces between the core tank and the exit ports or external shielding, as the case may be. Between the core tank and the broad-beam cell there is only graphite. Similarly, only graphite fills the space between the core tank and the external face shield where the instrumentation and activation ports lie. However, between the core tank and the exit ports of the two treatment rooms there exists a complex of reflector, moderator, screen, and filter, so that appropriate and requisite purity of emitted radiation can be attained. Approximately ¼ inch from the core tank is a wall of graphite 6 inches thick. From the center to the periphery, there are a ½-inch air gap and a 2-inch bismuth gamma shield encased in a spray coat of pure magnesium 1/30,000 inch in thickness. Then there is another ½-inch air gap, followed by another magnesium-encased bismuth gamma shield 5½ inches thick. This, in turn, is followed by another air gap, a thin magnesium window of AZ-31 alloy, another air gap, and then the tanks made of pure aluminum. The outside dimensions of the three tanks as one unit are 30½ inches wide and 31½ inches high, with each tank approximately 1½ inches thick. Then there is another air gap of approximately ⅜ inch, and another magnesium window which bounds the reactor fixed ports from the shutter mechanism. At present, in the shutter itself, there are 13 inches of graphite and then a final gamma shield of 4 inches of bismuth, with an air gap to the plastic wall in the shutter opening. Of the highest import is not only the purity of materials in these various components but also the geometry and the relationship of the components to one another. It is planned to fill one or more of the tanks with heavy water, which, it is believed, will provide very effective moderation and permit the selection, at will, of several average energy values of emergent neutron streams. Under maximum moderating conditions, it is believed the exit neutrons will be largely of thermal energies with a slow-to-fast ratio of 10^4. Thus it can be seen that by appropriate selection of moderating liquid, screen, filter, and shields, a variety of effects can be achieved. This system has not been tested, and it is hoped that these tests can be completed this fall.

It must be pointed out that the construction design is such that the entire system of moderators and shields leading to the exit ports in the treatment rooms can be removed as desired for alteration, substitution, or elimination of any given component part. Structurally, this is the system which markedly sets this reactor apart as a medical reactor. It is in the area of extensive exploration into the effects of configuration and materials on neutron number and quality that fields of medicine and engineering have a maximum joint problem in technology, since it is presumed that any future type of operating core can be fitted to the system which will be developed here.

The exit port can be varied in size from 10 by 10 centimeters to 40 by 40 centimeters, presumably with a relatively uniform neutron field over the mouth. Test runs have thus far shown a maximum flux of 2.4×10^{10} thermal neutrons per square centimeter over a 40-by-10-centimeter port. A thermal neutron is here defined as one with an energy of 0.025 electron volt. This is approximately one-tenth of the flux it was hoped would be obtained. However, by the time present tests are completed, it is believed the desired flux will be reached.

One face of the reactor has been left essentially bare except for graphite. This broad-beam cell (Fig. 8) is designed to permit various studies of shielding effectiveness in a "sea" of neutrons as well as to permit a wide variety of mammalian exposure studies. Tubes deep in the graphite reflector and ending tangent to the core tank are provided for production of radioactive isotopes of short half-life, as for therapeutic and diagnostic use.

The reactor will permit not only exploration of the practical application of neutron capture therapy, but also intricate studies of the mechanism of energy transfer to biological systems from neutrons of epithermal and intermediate energy. Studies in progress indicate that the effects upon cytological structures of the central nervous system of thermal neutrons are far below what might have been predicted. The reaction tubes will be utilized in studies of activation analysis, but these will by no means be limited to materials or specimens. In-vivo activation occurs during neutron capture therapy. The extent and nature of the activation are being studied by gamma spectroscopy as a first step. This is the first procedure which has been developed which

permits one to make any significant measurement of effective integrated thermal neutron infiltration.

In developing these and other studies the operational routine of the reactor will be markedly varied. It is hoped that it may be used for very large neutron burst pulses as well as more usual continuous operation. Thus far the maximum power level reached is 3 megawatts; the reactor design permits continuous operation at this power.

Brookhaven National Laboratory

While the reactor has been described largely in terms of its development of Brookhaven's medical program, it must be made clear that it is one dramatic representative product of the interplay between various scientific and engineering disciplines represented on Brookhaven's staff. In this environment the staff of the Medical Research Center is composed not only of medical department members but also of colleagues working daily within their own specialties, who come from the reactor operations, nuclear engineering, chemistry, physics, instrumentation, and health physics departments of the laboratory.

Brookhaven National Laboratory is a civilian academic establishment, operated under the guidance of nine major private universities of the Northeast area. They supervise its administration through a corporate entity, Associated Universities, Inc., chartered under the education laws of New York State.

Supporting funds are obtained by the corporation from the U.S. Atomic Energy Commission under terms of a specific contract (*4*).

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X-ray Emission from Television Sets

The gonad dose to the population is evaluated on the basis of laboratory and field measurements.

Carl B. Braestrup and Richard T. Mooney

It has long been realized that any electronic tube operating at a potential above a few thousand volts may be a source of x-radiation. The need for eliminating any resulting hazards received official recognition by the American Standards Association in 1946 (*1*). It was specified that the radiation level at any accessible region "shall not exceed 12.5 mr/hr"—that is, 100 milliroentgens per 8 hour day, the then-prevailing maximum permissible dose (MPD). The purpose of this requirement was to prevent radiation injury to the individual; no consideration was given to genetic effects at that time. The maximum permissible dose has since been progressively reduced; the present limit for radiation workers is an average of 100 mr per week.

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Since the publication of the reports of the International Commission on Radiological Protection (*2*), the National Academy of Sciences (*3*), and the British Medical Research Council (*4*), attention has been focused on the genetic effects of ionizing radiation. It is now agreed that the dose to the gonads should be kept as low as possible without sacrificing the many benefits associated with the use of radiation. For this reason, a further reduction has been made in the maximum permissible dose for persons not occupationally exposed. For individuals in the environs of radiation areas, the National Committee on Radiation Protection (*5*) has set the maximum permissible dose at 0.5 rem per year. An additional limit has been recommended for the exposure of large population groups. The National Academy of Sciences has proposed that the average exposure of the population's reproductive cells to radiation above the natural background, but including the contribution from medical exposure, should be limited to 10 r from conception to age 30. The International Commission on Radiological Protection has recommended that the genetic dose to the whole population from all sources, additional to the natural background, should not exceed 5 rems plus the lowest practicable contribution from medical exposure (*6*). Consequently, even sources of minute radiation are of interest if they affect a large percentage of the population. Yet there have been very few scientific publications concerning sources of nonuseful x-rays such as cathode-ray tubes, oscillographs, electron microscopes, and television and other electron tubes (*7*). Of these, home television is of particular genetic interest because a high percentage of the population is involved.

The present study includes an estimate of the average per capita dose to the gonads from home television sets, based on radiation measurements on representative types of television tubes and the results of laboratory depth dose measurements required to determine the actual dose to the gonads.

Instrumentation

Highly sensitive instruments are required to measure the low level of radiation. Scintillation and thin-window Geiger-Müller counters have the required sensitivity (*8*) but are quite dependent on wavelength. For quantita-

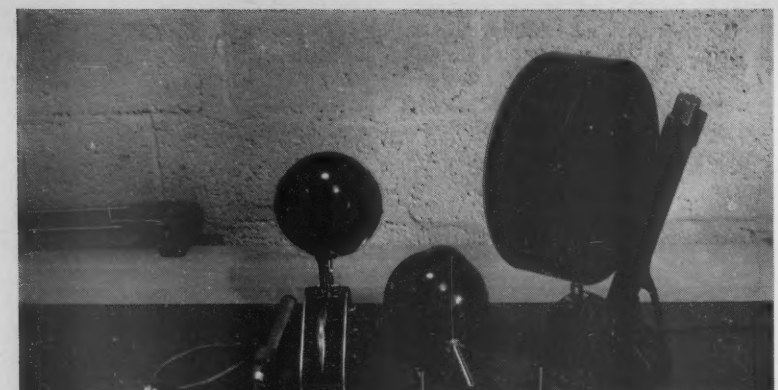

Fig. 1. Some of the chambers and electrometers used in this investigation.

tive measurements, use of condenser ionization chambers in conjunction with a sensitive electrometer was found to be most satisfactory. The condenser chamber has the advantage that the ionization can be integrated over a suitable period of time. The initial chamber, constructed in 1947 for television measurements, had three flat parallel electrodes, the center one consisting of a fine-mesh nylon gauze coated with aquadag to make it conductive. This design insured a relatively uniform electric field in the chamber, but by replacing the flat center electrode with an aluminum collector rod, the capacitance was decreased with a resultant increase in the sensitivity of the chamber. This type of chamber does not have a uniform electric field, but the interelectrode potential was found ample to prevent ion recombination in the low-level radiation fields of interest.

The potential across most home television picture tubes is relatively low, from 10 to 25 kv. The emitted radiation is essentially monochromatic, because of the high filtration effect of the heavy tube wall. Thus, the energy of the *emitted* radiation in thousands of electron volts corresponds to the accelerating potential in thousands of volts. It is still necessary, however, to use an ionization chamber with a thin window, for the x-rays are produced over a large area of the screen and enter the ionization chamber at different angles; with a thick-walled chamber, the resultant oblique filtration would cause significant dependence on energy which cannot be corrected for in its calibration against a standard open-air chamber using a nearly parallel beam from a very small target. The chambers used in this investigation had windows of polystyrene with a thickness of 0.5 mm, or less.

In addition to the chamber described above, spherical and cylindrical chambers were used when it was desirable to have minimum directional variation in sensitivity. Figure 1 illustrates some of the chambers and electrometers used in this investigation.

Tube Potential and Panel Distance

A beryllium window x-ray tube (AEG-50) was used to determine the attenuation of various types of viewing panels and samples of flat glass cut from such panels. The density of the samples (2.6 gm/cm^3) was slightly greater than that of clear plate glass (2.5 gm/cm^3) due to the presence of materials of higher atomic number. The x-ray tube was operated at constant potential of 15, 20 or 25 kv; the current was 20 ma. The x-ray tube was used also to determine the quality of the transmitted radiation and the percentage depth dose at the levels of the gonads.

The x-ray tube potential was determined by means of a milliammeter and a 125-megohm Taylor-type resistor. A Variac provided vernier control of the tube potential under load, while line fluctuations were minimized by means of a 2-kva voltage stabilizer. These precautions were necessary because of the great dependence of exposure rate on the tube voltage, as is illustrated in Fig. 2. As indicated, a similar relationship was obtained on a conventional 21-inch television tube. For the voltage range generally used on television sets, the x-ray emission varies approximately as the 20th power of the tube potential. Radiation measurements on television sets, therefore, have very little meaning unless the tube voltage has been very accurately established and maintained.

Most of the field measurements were made very close to the panel of the tube in order to secure sufficiently high readings and to minimize errors due to normal variations in background radiation. It was necessary, therefore, to establish the relationship between the radiation level at the panel and the level at the usual viewing distance, which is essentially equal to the gonad distance. A special television tube with a thin glass panel was used in order to obtain high readings at even greater distances. The thickness of the panel, however, was ample to insure nearly monochromatic radiation similar in quality to that obtained from a conventional television tube. Figure 3 shows the results of these measurements. It will be noted that there is no significant variation in the radiation level for distances within 8 cm of the surface. This might be expected, because of the large area of the radiation source. Between 8 and 100 cm, the reduction is considerably less than is indicated by the inverse square law. The relative radiation levels at various distances from the panel depend on the raster size and tube potential. Since the measurements were made with a large raster and high voltage, there is a maximum deviation from the inverse square law, and this graph, therefore, represents the worst condition that might be expected. It is obvious that this relationship is of primary importance in utilizing the results of measurements made at close distances.

Quality Determinations

Figure 4 shows the results of transmission measurements made at usual operating voltages with various thicknesses of flat samples of panel glass. It

Table 1. Half-value layers and corresponding energies.

Tube potential (kv)	Half-value layer		Energy (kev)
	Glass (mm)	Al (mm)	
15	0.17	0.30	14
20	0.34	0.60	19
25	0.60	1.10	24

will be observed that the transmission curves become straight lines for relatively thin samples of glass. Measurements were also made on actual panels 7 to 11 mm thick; their transmission curves were found to be linear extensions of those shown for the samples. Thus, the radiation emitted from television tubes is, as stated, essentially monochromatic. In addition, the curves indicate that only a minute fraction of the emitted radiation is transmitted through the glass panel. Even at an operating voltage of 20 kv, which is higher than that used on most black-and-white sets, the thinnest panel glass attenuated the radiation by a factor of more than 100 million. The attenuation coefficient at higher voltages is obviously less. This, however, is partially compensated for by the increased panel thickness, higher voltages being used mainly with larger-sized screens where the panel thickness has to be greater to insure adequate mechanical strength.

Even minute variations in the amount of materials of high atomic number present in the glass cause great changes in the attenuation coefficient (*9*). It is desirable, therefore, to establish the equivalence of glass in a pure material for production control. Aluminum was selected as the base for comparison because it is readily available and its absorption coefficient is not very different from that of glass.

Figure 5 shows the transmission curves in aluminum. These curves also serve to determine the quality of the radiation transmitted by the panel. Table 1 shows the half-value layers and corresponding energies. These values are essentially the same for all television tubes irrespective of the variations in thickness and composition of the glass. As is indicated, the half-value layer at 25 kv is approximately 1 mm of aluminum, a value frequently used in superficial therapy. Therapy depth dose tables, however, are of limited value in estimating the dose to the gonads from television sets because the radiation is more homogeneous and the source-skin distance is very much greater.

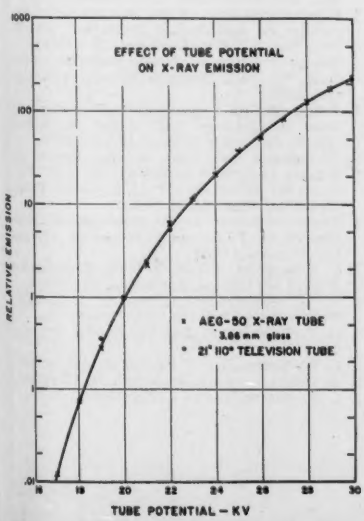

Fig. 2. Relative x-ray emission as a function of tube potential.

Depth Dose Measurements

Due to the low exposure rate from television tubes at the usual viewing distance, the depth dose measurements were made with a regular x-ray tube operating at 25 kv and 20 ma. The filtration was adjusted to give maximum exposure rate for the same quality of radiation as that obtained from a television tube. A target-skin distance of 100 cm was chosen, although adults, as a rule, view high-voltage, large-screen sets from a greater distance. The 100 cm allows for the tendency among children to view even large screens at short distances. This is an important consideration since the exposure of children is genetically more significant than the exposure of adults, many of whom have passed their reproductive age.

Measurements were made in a water phantom at 1 and 5 cm, the average depths of the testes and ovaries. The depth dose at 1 cm was found to be 75 percent, and at 5 cm, 10.8 percent, of the air exposure dose. Phantom measurements were not made at lower voltages because of the minute exposure rates and much higher absorption coefficients. However, attenuation measurements made at lower voltages indicate depth doses at 5 cm of the order of 0.01 percent for 15 kv and 2 percent for 20 kv. It is obvious, therefore, that the tube voltage has the most influence on the magnitude of the dose to the

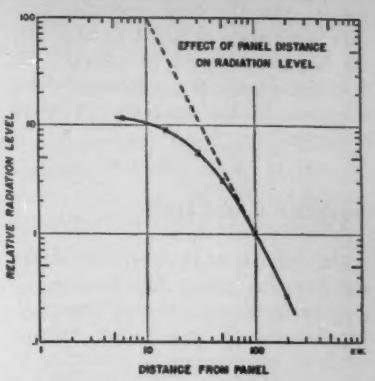

Fig. 3. Effect of panel distance on radiation level.

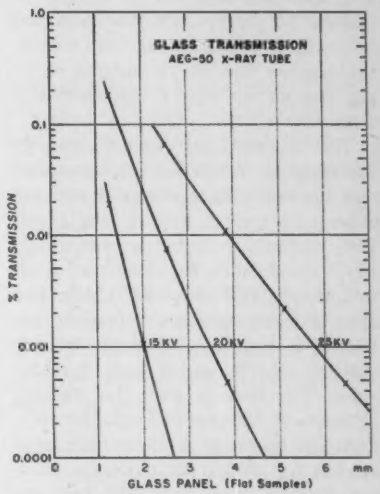

Fig. 4. Glass panel transmission curves.

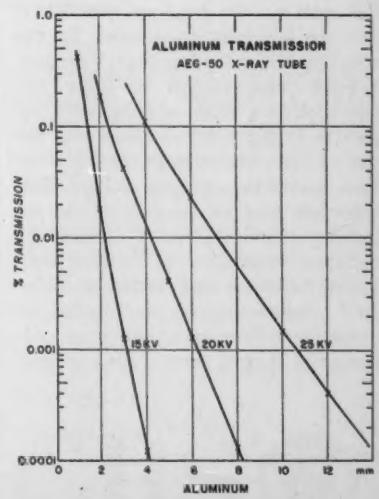

Fig. 5. Aluminum transmission curves.

gonads. For the usual operating voltages, a variation of just 1 kv may vary the dose to the ovaries by a factor of 6; it is not merely the percentage depth dose but also the exposure rate which is affected.

Population Gonad Dose

The estimate of the television contribution to the gonad dose requires, in addition to the data already presented, information concerning the viewing habits of the population. According to estimates obtained from the industry and other sources, approximately 55 million homes in the United States have television sets; the average viewing time is 5 hours per day, and the number of viewers 2.2 persons. On this basis, and assuming a population of 180 million, the average number of viewing hours per person per year is approximately 1000.

The International Commission on Radiological Protection recommended that the emission of x-rays should not exceed 2.1 mr per hour at any accessible surface on home television sets (*2*). Consideration has since been given to lowering this value to 0.5 mr per hour at 5 cm from any accessible surface of the set. Table 2 shows the calculation of the gonad dose for this value. The dose is given for viewing distances of 100 and 200 cm. However, most sets operating at 25 kv have large screens for which the optimum viewing distance is at least 200 cm; the resulting yearly average gonad dose is less than 5 mrad. The gonad dose due to natural background radiation is of the order of 100 mrad per year (*10*); thus the television contribution for the above conditions is less than 5 percent.

Field measurements of some 200 television sets show a progressive reduction in the x-ray emission over the last 12 years even though the trend has been toward use of higher voltage. This reduction may be ascribed to the increasing attention given to the need for radiation protection. In general, television tubes are not marketed today until measurements on pilot models indicate acceptable radiation levels. Although at present there are no national recommendations specifying the maximum permissible x-ray emission from television sets, television tubes, in general, are designed so that the maximum emission at a distance of 5 cm from the tube surface is less than 0.5 mr per hour.

Table 2. Calculation of per capita gonad dose.

Average yearly viewing time	1000 hr /person	
Operating potential	25 kv	
Radiation level 5 cm from screen	0.5 mr /hr	
Viewing distance	100 cm	200 cm
Correction factor for distance (see Fig. 3)	0.08	0.02
Depth dose:		
at 1 cm (male)	75%	75%
at 5 cm (female)	10.8%	11.3%
Yearly gonad dose:		
Male	30 mrad	7.5 mrad
Female	4.4 mrad	1.1 mrad
Average	17.2 mrad	4.3 mrad

Most sets have a safety glass in front of the screen to provide protection in case of implosion. This glass reduces the radiation transmitted by the panel to a few percent. As a result, the average gonad dose from home television sets is much less than 1 percent of that due to normal background radiation.

Other Sources of Nonuseful X-rays

So far, only the radiation transmitted by the panel of the television tube has been considered. The radiation transmitted by the funnel and other parts of the tube may actually be greater; in addition, the high-voltage rectifier may serve as a source of radiation. Usually, only the radiation transmitted by the panel is directed toward the viewer; the other sources of radiation are, therefore, of little genetic significance. However, the possibility of somatic injuries to personnel during testing and servicing should not be overlooked.

Consideration should also be given to possible somatic injury to personnel operating and servicing theater-projection-type television tubes, closed circuit television, cathode ray oscilloscopes, klystrons, electron microscopes, and devices incorporating high-voltage rectifiers. Measurements have indicated radiation levels as high as 1 r per hour in the vicinity of some of these, indicating that none should be considered safe until so established by dependable radiation measurements.

Conclusion

The results of this study indicate clearly that the possibility of somatic radiation injuries to the viewer from conventional television sets is extremely remote. From a genetic point of view, a permissible radiation level of 0.5 mr per hour 5 cm from any accessible surface of the equipment appears reasonable and will not require any changes in most existing sets. Even if all sets emitted radiation at this rate the contribution to the gonad dose at usual viewing distances would still be less than 5 percent of that due to the average natural background radiation. Furthermore, since sets meeting the above requirement must be so constructed that the x-ray emission does not exceed 0.5 mr per hour at the maximum operating voltage, the exposure dose rate under average conditions will be much lower. For instance, lowering the voltage from 25 to 20 kv will reduce the radiation level by a factor of 36 and the average gonad dose by a factor of 124. Thus, for actual viewing conditions the television contribution to the gonad dose will be insignificant compared with the differences in natural background radiation between various localities.

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SEE?

(A cage in the Primate Laboratory of the University of Wisconsin. A rhesus monkey can be seen seizing a cloth pad held out by Prof. Harry F. Harlow, past President of the American Psychological Association.)

Dr. Harlow: ". . . This simple basic reaction made us believe we could define and measure what had previously been undefinable and unmeasurable—a baby's love for its mother. To create an inanimate substitute mother over which we would have complete experimental control . . . we constructed . . . a cloth mother . . . and a wire mother . . . We deliberately made the faces different . . ."

This scene and these words will be seen and heard on television screens in millions of homes throughout the nation on Sunday November 1 at 5 pm EST when *Conquest*, the distinguished series of science programs, will inaugurate its third season on the CBS Television Network.

It is one of the early frames of a remarkable series of film sequences in which Dr. Harlow, a noted psychologist, reveals many fascinating and unexpected reactions of babies to their mothers and presents some startling conclusions on mother love, based on a series of controlled experiments with monkeys.

In six widely acclaimed hour-long programs over the past two years, *Conquest* has presented penetrating studies of both the stratosphere and the ocean floor, probed the structure of the human heart and brain, and explored the depths of a volcano. This season it will expand its efforts in a series of twenty half-hour Sunday afternoon programs produced by the Public Affairs Department of CBS News in cooperation with the American Association for the Advancement of Science.

As in the past, it will again be sponsored by the Monsanto Chemical Company which has recognized its important contribution in generating national interest in the field of science and increasing public awareness of the shortages in this area.

Early this month *Conquest* received its most recent honors, when it became the only network television program to win the 1959 Howard W. Blakeslee Award of the American Heart Association, for its dramatic report on open heart surgery.

Conquest's past performance has moved the well-known television critic, John Crosby, to describe it as "the most interesting and sophisticated (science program) . . . I have seen. I mean simply that *Conquest's* technique of discussing and explaining difficult scientific advances is being handled easily and colloquially and without any loss of precision. This is a very great feat."

Just how great a feat it is you will have a chance to judge for yourself by keeping your eyes firmly fixed Sunday afternoons on the CBS Television Network. Here are a few of the additional programs you can look forward to in the immediate future.

November 8 **THE BOTTOM OF THE SEA** *Conquest* follows the bathyscaphe "Trieste" as it dives 4000 feet to observe life in the depths on the floor of the Pacific Ocean.

November 15 **THE WORLD OF TB** Dr. Rene J. Dubos of the Rockefeller Institute for Medical Research presents experiments demonstrating that proper diet can increase resistance to tuberculosis.

November 29 **THE LADDER OF LIFE** On the occasion of the 100th anniversary of Darwin's "Origin of the Species" Dr. Julian Huxley and Dr. H. B. D. Kettlewell offer contemporary evidence illustrating the theory of evolution.

December 6 **THE LANDING BARRIER** A plane that flies at supersonic speed and lands as slowly as a helicopter is the goal of aeronautical science. *Conquest* reports on the progress being made toward this goal at Princeton University.

CBS

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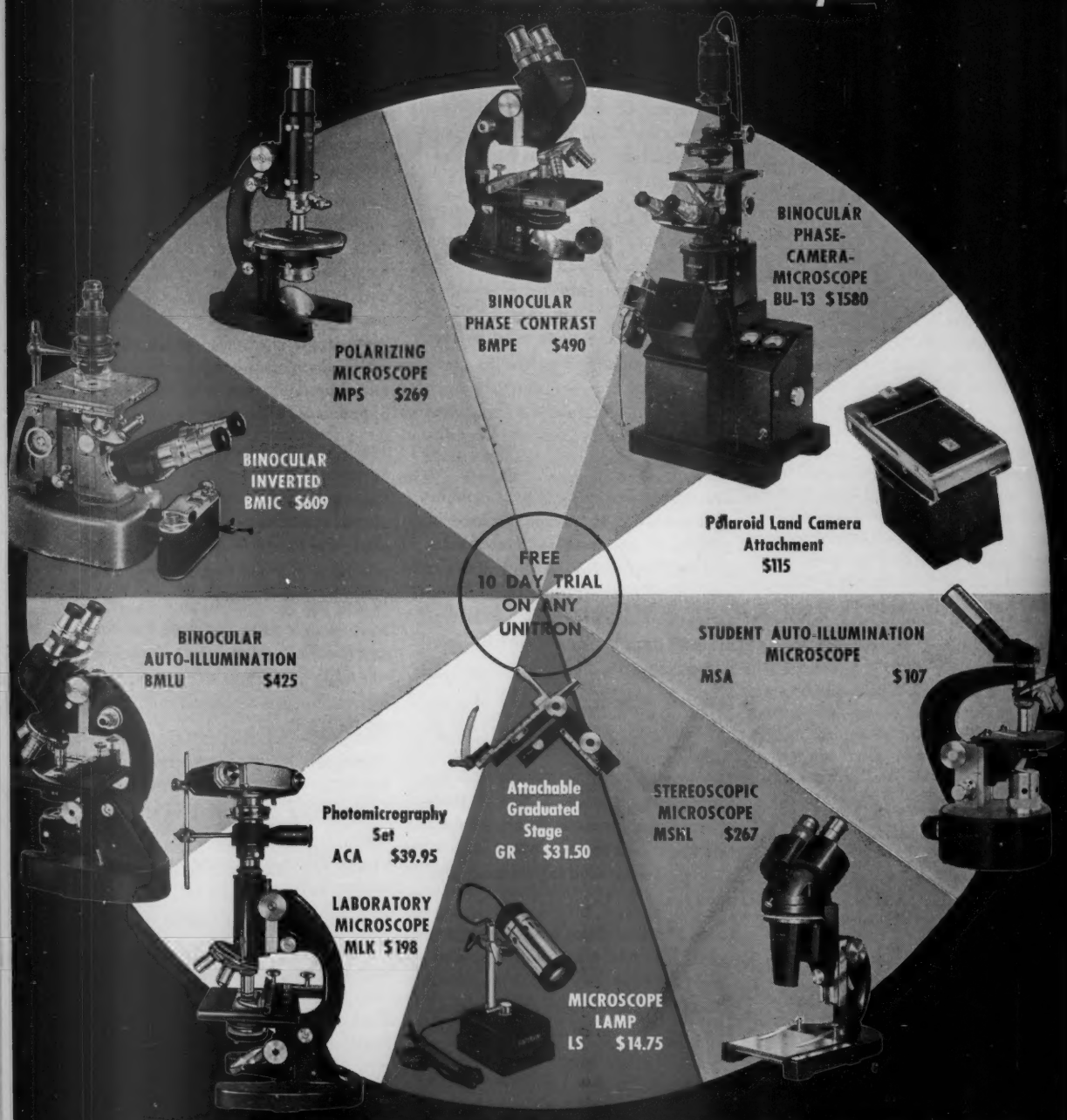
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Pierre Simon Laplace...on the store of higher knowledge

"Astronomy considered in its entirety is the finest monument of the human mind, the noblest essay of its intelligence. Seduced by the illusions of the senses and of self-pride, for a long time man considered himself as the centre of the movement of the stars; his vainglory has been punished by the terrors which its own ideas have inspired. At last the efforts of several centuries brushed aside the veil which concealed the system of the world. We discover ourselves upon a planet, itself almost imperceptible in the vast extent of the solar system, which in its turn is only an insensible point in the immensity of space. The sublime results to which this discovery has led should console us for our extreme littleness, and the rank which it assigns to the earth. Let us treasure with solicitude, let us add to as we may, this store of higher knowledge, the most exquisite treasure of thinking beings."

—Exposition du Système du Monde, 1796.

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Respiratory Carbon Dioxide Response Curve Computer

It gives more complete alveolar ventilation-P_{CO_2} response curves than could formerly be obtained.

J. Weldon Bellville and J. C. Seed

The time and effort required to analyze and plot data for alveolar ventilation-alveolar P_{CO_2} response curves has constituted a serious limitation to their ready use. The advent of rapid automatic carbon dioxide gas analyzers and the pneumotachograph has made the accumulation of the basic data needed for such a plot fairly simple. However, the reduction of continuous automatic records of both carbon dioxide concentration and volume of expired air to the response curve has been tedious and time consuming. Moreover, because of the labor involved it could be done at only a few specified points for each curve despite the fact that the basic data were such as to permit a continuous plot. To overcome these limitations, a respiratory computer which carries out the calculations continuously and automatically has been built.

The basic method employed depends on rebreathing endogenous carbon dioxide and has been previously described (*1*). It represents a modification of the method described by Eckenhoff, Helrich, and Hege (*2*). The subject is fitted with a nose clip and a rubber metabolism mouthpiece which connects to a one-way flutter valve. There are two three-way valves in the circuit so that with both valves closed and a measured amount of oxygen in the system, the subject rebreathes in a closed-circle system (Fig. 1). As the endogenous CO_2 accumulates in the system, the alveolar P_{CO_2} steadily increases, and with it alveolar ventilation. It is these two steadily increasing values which are finally plotted against one another. The rate of increase of alveolar P_{CO_2} is about 3 mm-Hg P_{CO_2} per minute, and this rate of increase is maintained for about 8 minutes.

In order to compute alveolar ventilation (V_A), the tidal volume (TV), physiologic dead space (DS), and frequency (f) must be known. The rate of air flow during respiration is measured. This is integrated to give tidal volume. This tidal volume is corrected to standard conditions ($BTPS$). Physiologic dead space, calculated according to the cylindrical formula of Gray (*3*), is subtracted out to give an alveolar volume. The alveolar tidal volumes for a given time interval are added together to give an alveolar ventilation in liters per minute.

$$V_A = \sum_{t=0}^{t=1} \left[\left(\int f \, dt \right) \times \frac{BP}{760} \times \frac{310}{760 - VP} - \left(\frac{DS_0}{8TV} + DS_0 \right) \right]$$

The calculations involved in obtaining an alveolar P_{CO_2} are as follows: Inhaled and exhaled air are continuously sampled, and the carbon dioxide content is measured. The highest concentration of CO_2 in each exhalation is recorded and taken as an index of the alveolar P_{CO_2}.

The method for accumulating data and carrying out the calculations is indicated in Fig. 1. The carbon dioxide content in the exhaled air sampled at the lips by a microcatheter technique is analyzed in an infrared Liston-Becker CO_2 gas analyzer (*4*). The amplified output of the CO_2 infrared pickup unit is then fed into an instrument linearizer (*5*) which is set up so that the output voltage is linearly proportional to the CO_2 concentration in the infrared pickup unit. The voltage from the instrument linearizer representing the instantaneous CO_2 concentration in the exhaled air is fed to the analog computer (*6*), where the voltage representing the highest CO_2 concentration in each breath is detected, held, and fed onto the x-axis of an x-y plotter (*7*).

The flow of exhaled air is detected by measuring the pressure drop across a fine-mesh screen (*8*). The output from the strain-gauge manometer is amplified in a carrier-type amplifier (*9*) and fed into the analog computer. In the computer the flow for each exhalation is integrated to obtain the tidal volume. The computer then corrects this volume of air to a volume at standard pressure, and a thermistor feeds into the computer from the rebreathing system so that a correction to body temperature saturated with water vapor can be carried out. In the computer the operations are carried out for determining the physiologic dead space and subtracting it from the tidal volume so that a running average can be taken and expressed as alveolar ventilation. The voltage output from the analog computer representing alveolar ventilation in liters per minute is then fed onto the y-axis of an x-y plotter.

Carbon Dioxide Measurement

Carbon dioxide concentration in the exhaled air is sampled by a microcatheter technique from the level of the lips. A 4-cm polyethylene catheter introduced through a low-resistance, one-way respiratory valve (Warren E. Collins–J-2 valve) has its tip terminating at the level of the lips. A continuous sample of air is drawn through the microcatheter cell at a constant rate of 500 ml per minute and then returned to the circle system. With this flow of gas through the CO_2 gas analyzer and the delay of the analyzer, the over-all response time is approximately 1/5 second. The CO_2 gas analyzer is calibrated before and after each run by introducing from separate cylinders appropriate concentrations of carbon dioxide in oxygen. The contents of each cylinder mixture are assayed by the micro-Scholander

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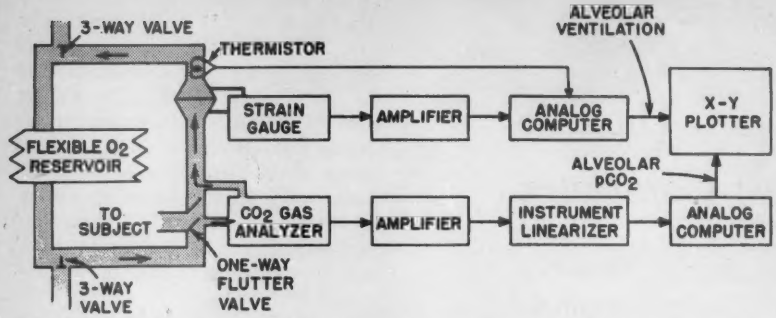

Fig. 1. Rebreathing circuits, sensing elements, amplifiers, computers and *x-y* plotter.

technique. The P_{co_2} measurements are accurate to within 0.5 mm-Hg.

The calibration curve for voltage output of the CO_2 analyzer versus percentage of carbon dioxide in the microcatheter cell is not a linear function. Therefore, in order to correct the output of the CO_2 analyzer so that the voltage is linearly proportional to the percentage of carbon dioxide drawn through the microcatheter cell, an instrument linearizer is used. This instrument is designed so that a variable correction voltage is automatically and continuously added to or subtracted from the input voltage to give a voltage output that is linearly proportional to the carbon dioxide concentration in the microcatheter cell.

P_{co_2} Calculation

The end expiratory P_{co_2} is taken as an index of alveolar P_{co_2} (*10*). The end expiratory P_{co_2}, which is the highest P_{co_2} obtained during exhalation, is detected by means of a peak-voltage follower (stage 1, Fig. 2; Fig. 3). The output of the peak-voltage follower representing the peak voltage obtained during exhalation is held on a 0.2-μf capacitor (Fig. 3) which represents a sequential charge transfer or "delay line." The capacitor is connected to terminal 15 of a four-pole, double-throw relay (6HY4C) so that, as exhalation ends, the peak voltage stored during that exhalation is presented to the voltage-follower stage (stage 2, Fig. 2; Fig. 3). The voltage-follower stage then holds this peak voltage throughout inspiration and the following exhalation. At the end of this exhalation it resets to the peak voltage of the exhalation. Working in tandem with this set of relay contacts is the 50,000-ohm resistor attached to terminal 14 of the relay. The circuit connected to relay contact 14 serves to discharge the 0.05 μf capacitor during inhalation so that it is ready to follow the peak voltage of the next exhalation. The output of stage 2, the voltage follower, then feeds the *x*-axis of an *x-y* plotter. In this way a voltage is constantly applied to the *x*-axis, which represents the peak P_{co_2} attained on the previous breath.

The response times of the electrical components along the CO_2 axis are quite adequate for physiologic work. The CO_2 analyzer reaches 90 percent of full scale in 0.1 second. Since expiration seldom lasts less than 1 second, and since the concentration of CO_2 rises very fast at first and then slowly toward the end of expiration, this response time is more than adequate; moreover, the deeper the respiration the more accurate the CO_2 analysis. The instrument linearizer requires approximately 0.1 msec to reach 99 percent of full-scale deflection. Because of the delay line, the actual recording of each CO_2 concentration is one breath behind all the time. Hence the major delay in recording CO_2 concentration depends on the frequency of respiration.

Measuring Flow

The flow in the rebreathing system is measured by determining the differential pressure across a fine-mesh screen. Since condensation of moisture on this screen would increase the resistance to air flow and thus would interfere with flow measurements, the flow meter is wrapped with heating tapes so that condensation does not take place. The flow meter is linear over the range of flows encountered during rebreathing. The differential strain-gauge manometer is connected into a carrier-type amplifier. The output of this amplifier is a push-pull or double-ended signal which must be converted to a single-ended signal in the analog computer for further processing.

Alveolar Ventilation Calculation

The first stage of the analog computer (stage 3, Fig. 2; Fig. 3) is a subtractor stage. This stage converts the push-pull or positive and negative signal from the carrier amplifier into a single-ended signal which is then fed through the rest of the computer. This single-ended signal is fed simultaneously to two stages, a voltage detector (stage 4, Fig. 2; Fig. 3) and an integrator (K3J, Fig. 2; Fig. 3). The voltage detector stage is designed to control

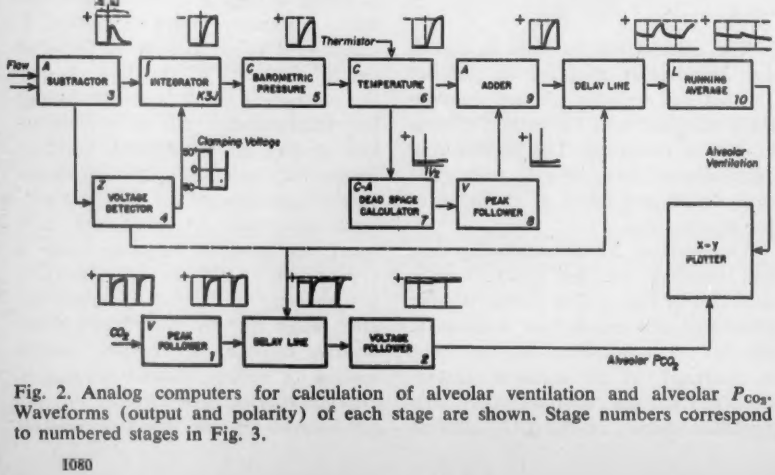

Fig. 2. Analog computers for calculation of alveolar ventilation and alveolar P_{co_2}. Waveforms (output and polarity) of each stage are shown. Stage numbers correspond to numbered stages in Fig. 3.

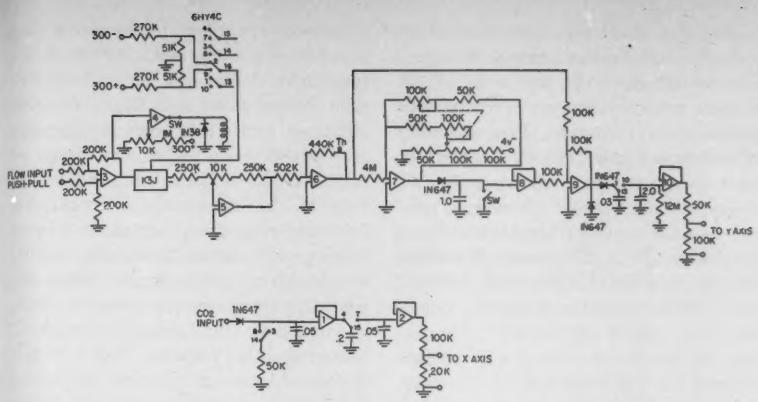

Fig. 3. Analog computers for calculating alveolar P_{CO_2} and alveolar ventilation. Each stage (numbers in triangles) represents an operational amplifier type K2W (George A. Philbrick Researches, Inc.). All relay contacts are shown in the deenergized (exhalation) position.

a relay (6HY4C) (Fig. 3). As soon as the input voltage becomes positive, the relay is deenergized (beginning of exhalation), and when the signal becomes zero (end of exhalation) the relay is energized. This relay controls the two sequential charge-transfer or delay lines, one delay line in the CO_2 section (terminals 14 and 15, Fig. 3) and one delay line in the running average section (terminal 13, Fig. 3), and in addition generates a $\pm$50-volt clamping voltage (terminal 16, Fig. 3) to the K3J integrator.

The second output of the subtractor stage representing flow is integrated by the K3J integrator. The integration time interval is controlled by the $\pm$50-volt clamping voltage generated by the relay (terminal 16, Fig. 4). Thus, as soon as the voltage output from the subtractor becomes positive—that is, as soon as expiration starts—integration begins. Integration of flow in the K3J continues until the output of the subtractor stage returns to zero—that is, until expiration ends. The output of the K3J integrator represents tidal volume under nonstandard conditions.

The correction to standard barometric pressure is a simple coefficient function. It involves setting the gain of this stage (stage 4, Fig. 2; Fig. 3) so that the output of the K3J integrator is multiplied by barometric pressure divided by 760 mm-Hg. This stage is initially calibrated so that this setting is a convenient front panel dial adjustment. The output of the fifth stage, then, represents tidal volume corrected for barometric pressure.

In stage 6, (Figs. 2 and 3) the correction to a volume of gas at body temperature saturated with water vapor is carried out. A thermistor located immediately after the flow meter is part of a resistance network which determines the gain of stage 6 so that it automatically varies in such a manner that the output will represent a gas volume corrected to body temperature saturated with water vapor. In the resistance network shown for stage 6 in Fig. 3, the values are calculated on the basis of a calibration of our particular thermistor. The output of stage 6, then representing a tidal volume at standard conditions, is then fed simultaneously to an adder stage, stage 9, as well as to a dead-space calculator stage, stage 7.

In the dead-space calculator stage, stage 7, the physiologic dead space is calculated according to the cylindrical formula of Gray (*3*):

$$DS = \frac{DS_0}{8TV} + DS_0$$

The value for DS_0, the theoretical dead space at zero ventilation, is calculated for each individual from the Bohr equation (*11*). This value is introduced by presetting the triple ganged 100,000-ohm potentiometer which is located to the extreme right on the front panel of the computer (Fig. 4). The first term DS_0 alone is introduced by the voltage divider network and 4-volt bias cell, while the second term is generated by the other two resistance networks in combination with the 4-megohm input resistance and the output from stage 6. The output of the dead-space calculator is then held on a peak follower, stage 8.

The correction term for dead space is the peak voltage generated by stage 7. This peak voltage is obtained in stage 8 and stored there for subtraction from the corrected tidal volume in stage 9. This peak follower circuit does not reset to zero after each breath, since during rebreathing the tidal volume increases progressively and the physiologic dead space increases progressively. Before a new run is begun, the peak follower must be manually reset to the DS_0 value. This is accomplished by short-circuiting the 1 μf capacitor

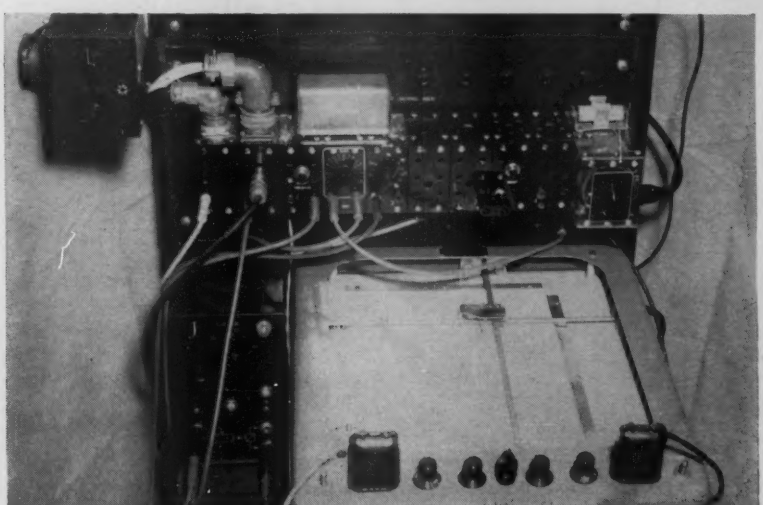

Fig. 4. Analog computer and *x-y* plotter. Calibrator is shown on the extreme upper left. The K3J integrator (George A. Philbrick Researches, Inc.) is to the left of the *x-y* plotter.

to ground through a reset switch (SW) located on the front panel of the computer.

In stage 9 the physiologic dead space is subtracted from the tidal volume. This is done with an adder circuit rather than a subtractor circuit, since the output of the dead-space calculator is inverted from its input voltage and we have two signals of opposite polarity. The peak output of the adder stage, stage 9, is a voltage which represents an alveolar volume.

The capacitor connected to terminal 13 of the relay serves to record the peak voltage output of stage 9. The capacitor and accompanying relay switch and diodes constitute the delay line of Fig. 2. At the end of each expiration, this capacitor is discharged into the running-average circuit, stage 10 (Figs. 2 and 3).

Alveolar ventilation is the sum of all alveolar volumes occurring during 1 minute. Thus, it is the sum of all charges accumulating on the delay line capacitor in 1 minute. This summing operation is carried out by transferring each charge to the 2.0-μf capacitor of stage 10. The rate of transfer is governed by the rhythm of breathing. Thus, frequency (f) is taken into consideration at this point. The time interval over which the sums are taken is determined by the decay time of the 12-megohm resistor and the 2-μf capacitor of stage 10. The output of this running-average circuit is then introduced onto the y axis of the x-y plotter.

The limiting factor in the response time of the ventilation axis is the final averaging circuit and the frequency of respiration. All electrical components except the averaging circuit perform at speeds far in excess of those needed for accurate measurement at maximum rates and depths of ventilation. The time constant of the final averaging circuit is such that with a respiratory rate of 20 per minute 50 percent of full-scale response is obtained in 17 seconds. At faster rates of respiration full-scale response is obtained sooner. During a response curve run ventilation builds up gradually and hence the recording lag is never as great as would be implied by a half-time of 17 seconds. Moreover, the response curve is not determined as an absolute value in itself but for comparison with other curves run under similar conditions—here the lag due to the averaging circuit is insignificant. In actual practice plots of alveolar ventilation-alveolar CO_2 curves obtained from continuous, direct, separate recordings of ventilation and CO_2 concentration are the same as those obtained by the computer from the same experimental data.

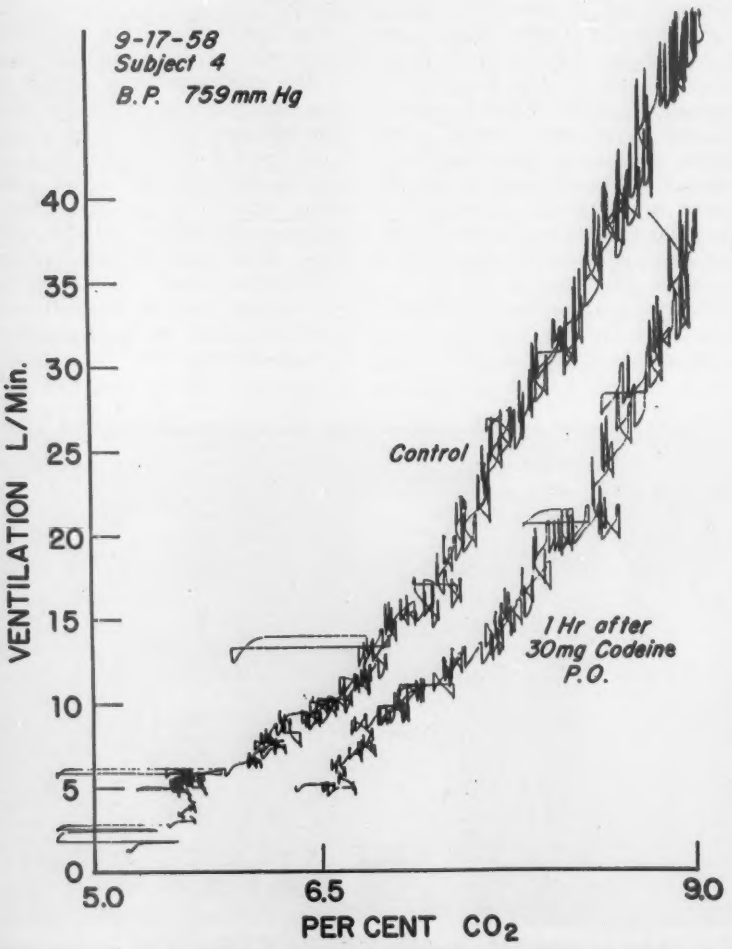

Fig. 5. Plot of alveolar ventilation versus alveolar CO_2; 4.98, 6.50, and 9.08 percent CO_2 were used for routine calibration of the x-axis.

x-y Plotter

The x-y plotter is a servo-driven potentiometer balance-type recorder. There are two separate amplifiers, one for each axis, so that information on the x-axis energizes the x-mandrel, while information fed on the y-axis energizes the y-mandrel. A pen is suspended between these mandrels, and it continuously plots out a function of x versus y. The particular type x-y plotter used in this application takes standard 8½ by 11 inch graph paper and has separate gain and zero controls for each axis. A typical record of plots obtained before and after administration of a drug is shown in Fig. 5.

Calibrating the System

In order to calibrate the infrared CO_2 gas analyzer, known concentrations of carbon dioxide in oxygen (4 and 9 percent) are introduced into the microcatheter sampling cell. The instrument linearizer is then checked by introducing mixtures of 5, 6.5, and 9 percent CO_2 in oxygen, and the output is adjusted for linearity. Simultaneously with the calibration of the instrument linearizer, the x-axis on the x-y plotter is calibrated so that the left-hand margin of the graph paper is represented by 5 percent CO_2 and the right hand margin by 9 percent CO_2,

and the intermediate gas concentration falls in the appropriate position.

Calibration of the *y*-axis of the *x*-*y* plotter is a bit more complicated. The strain-gauge manometer and amplifier are calibrated daily by introducing a gas flow of 50 liters per minute of O_2 from a precision-calibrated rotameter (*12*). Bias controls for stages 3 through 10 are adjusted for zero output with zero input. The zero bias of the *y*-axis of the *x*-*y* recorder is adjusted so that the pen is at the bottom of the graph paper. By means of an appropriate timing device, a standard voltage is introduced at the delay line following stage 9, and the relay is actuated every 3 seconds. The gain of the *y*-axis of the *x*-*y* plotter is then adjusted to 80 percent of full-scale deflection. A standard voltage representing a known volume of gas (approximately 2.3 liters) is then applied to the integrator by means of the same timing mechanism, and the reading on the *y*-axis of the recorder is checked. This reading corresponds to an alveolar ventilation of 40 liters per minute.

Discussion

The alveolar ventilation-alveolar P_{CO_2} response curve is one of the most sensitive and precise ways of assessing the effects of drugs upon respiration. Since we desired to study the effects of a number of drugs on respiration, it was more efficient to build a computer to carry out the operations automatically rather than to continue doing them by hand. Furthermore, a continuous plot gives a more complete picture of the final result and produces it while the data are being collected. Control response curves are very reproducible in the same subject within 1 mm-Hg P_{CO_2}. If the subject becomes at all drowsy during a run, it is immediately apparent as respiratory depression (a shift to the right), and the subject can be reminded to stay awake.

The effects of drugs on respiration are assessed by running two control response curves and then administering the medication. At 1, 2, and 3 hours after medication, repeat response curves are determined. In the work to date with narcotic-type analgesics, the effect of drug has been primarily to displace the response curve toward higher values of P_{CO_2} but the after-drug curve has been essentially parallel to the control response curve at P_{CO_2} values above 55 mm-Hg. An effect of narcotics on the slope of the response curve has been reported by other workers, but this is probably attributable to a failure to achieve sufficiently high values of P_{CO_2}. The respiratory depression produced after oral administration of 30 milligrams of codeine is readily apparent with the method we have described. The respiratory computer and other electronic equipment described here serve as further illustrations of how analog computers may readily be used to solve computational problems in the biological sciences. The whole system has been assembled from standard parts. The analog computer part of the system consists of a commercial 10-stage operational amplifier, and the computing operations are carried out by a series of home-made operational plug-in units made from modular assembly units. Two aspects of the computing operations are worthy of further comment and might be applicable to a number of other biological problems. These are the delay lines and the dead-space computer.

The delay line in the calculation of alveolar P_{CO_2} makes it possible to read out a constant CO_2 value while the preceding peak-follower stage is resetting, so that it may follow the peak CO_2 value of the next breath. At the end of this breath the CO_2 value being read out is reset to that of the breath just completed. The CO_2 value read out follows variations in alveolar P_{CO_2} up and down from breath to breath. For rapid following it is important that the capacitor on the input of stage 2, Fig. 3 (0.05 μf) be smaller than the one on relay terminal 15 (0.2 μf).

The delay line in the alveolar ventilation computation, although somewhat similar in construction to the P_{CO_2} delay line, performs a different function. At the end of expiration the charge accumulated on the 0.03 μf capacitor connected to relay contact 13 represents a volume of alveolar air. The injection of this charge at the end of expiration into the running-average stage permits the read-out of alveolar ventilation in liters per minute. Frequency of breathing as well as depth is taken into consideration in this circuit, since the end of expiration determines when the charge representing alveolar air will be injected into the averaging circuit. Thus, the four-pole, double-throw relay controls integration and coordinates the presentation of data to the *x*-*y* recorder.

The dead-space calculator is a novel circuit for carrying out the operation of multiplying a function by a coefficient and adding a constant to this product. This is done with only one operational stage. The key to the solution of this problem is a precision triple-ganged potentiometer.

Summary

The respiratory computer described here makes it possible to obtain more accurate and precise alveolar ventilation-P_{CO_2} response curves than formerly and with fewer man-hours of labor. It is hoped that the ease of obtaining these response curves will lead to their more frequent use in evaluating respiratory phenomena. Clinical applications in evaluating the effects of changes in compliance and airway resistance on respiration are readily apparent. This technique is being used to study the degree of respiratory depression caused by narcotics and anesthetics and to study the effects of stimulating drugs. Respiratory stimulation and depression in a variety of disease states are also being pursued (*13*).

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A Simplified Microspectrophotometer

Cadmium selenide cells are well suited for absorption microspectroscopy of pigments in living systems.

G. K. Strother and J. J. Wolken

The use of sensitive high-speed spectrophotometry for the investigation of the pigment system within living plant and animal cells has only begun to be investigated. Recent progress in this research has been summarized in several reviews (*1*, *2*). The methods of precision spectrophotometry still require fairly complicated apparatus, and all employ a photomultiplier tube as the light-sensitive photocell.

A microspectrophotometer using solid-state electronic components has been constructed in our laboratory and is being used to investigate pigmented structures in living cells. The light-sensitive element is a cadmium selenide photoconductive cell. The photocell output is amplified by a transistorized d-c amplifier and displayed on an oscilloscope used as a d-c voltmeter. For some time, photoconductive cells have been used for spectral measurements in the infrared region. More recently they have been used for x-ray spectroscopy (*3*). However, the present application of these cells to visible and ultraviolet microspectrophotometry is novel.

In Fig. 1 are shown a diagram of the instrumental setup and a photograph of the assembled apparatus in use. Light from source *L* enters a grating monochromator *G*, as shown by the dotted line. The exit slit of the monochromator is focused by a quartz lens on the condenser of microscope *M*. After passing through the specimen, the light beam hits the photosensitive cell *C*, which is accurately positioned relative to the image and located 25 centimeters above the eyepiece of the microscope. The electrical signal from the photocell is amplified by the d-c amplifier *A* and displayed on a Dumont model 403 oscilloscope *D*. The oscilloscope is used here because of its high d-c amplification capabilities; a high-impedance voltmeter would be just as satisfactory.

The microspectrophotometer uses either a xenon arc or a tungsten ribbon filament light source, a Bausch & Lomb 250-mm grating monochromator, and reflecting microscope optics (50 ×, with numerical aperture of 0.5) purchased from the American Optical Co. With these components, the instrument is usable over the wavelength range from 200 to 990 mμ (millimicrons) in a single sweep for specimen areas of 16 μ^2. For specimen areas of the order of 2 μ^2, the useful range is 270 to 990 mμ. With a tungsten ribbon light source, the useful range is 370 to 900 mμ.

The actual construction of the instrument was greatly facilitated by taking advantage of a photomicroscopy setup, as shown in Fig. 1. The lower end of a rubber, light-tight bellows fits over the eyepiece of the microscope. The upper end of the bellows fits into a light-tight tube. At the other end of the tube may be placed either the ground-glass viewer or the photocell holder, by operating a sliding track. The entire upper assembly is swung into place by means of a vertical bar arrangement mounted on a base plate. The height of the photocell can be adjusted by telescoping the tube supporting it.

The photoconductive cells being used at present are general-purpose cells made by the Clairex Corp. of New York. Two sizes are available, with sensitive areas of 0.5 by 1 and 1.6 by 4.7 millimeters. For a magnification of 500, these sizes represent specimen areas of about 2 and 30 μ^2, respectively. The spectral response of the cadmium selenide cells extends all the way from the far ultraviolet to the near infrared, with a rather sharp cutoff at about 1 μ. The peak response is in the visible region of the spectrum. At high light intensity, the time constant of the cell is of the order of milliseconds. At extremely low light levels, the time constant is of the order of seconds. The sensitivity of the photocells per unit area is comparable to photomultiplier tube performance.

In practice, the photocell acts as a light-sensitive resistor. In the dark, its resistance is greater than 100 megohms. In strong light its resistance decreases to the order of 1 megohm or less. The photocell used here is connected in series with a bias battery (70 to 100 volts) and a load resistor of 1 megohm. The load resistor serves as the input to the photocell amplifier, which is chopper-stabilized and battery-powered. The circuit employs two transistors in the common emitter configuration. Further d-c amplification is furnished by the oscilloscope used for output readings.

With the exception of arrangements similar to the one used by Denton (*4*), microspectrophotometers are generally rather elaborate instruments (*1*, *5*, *6*). They employ either split- or dual-beam optical systems with mechanical beam-chopping devices, voltage-regulated photomultiplier tubes with feedback mechanisms, and automatic-recording outputs. The final result of this type of instrumentation is a quantitative measurement of the optical density of a given specimen with an instrumental error of less than 5 percent. Measurements from the ultraviolet through the visible range are recorded in a few minutes, and response times of the instruments are usually of the order of a few milliseconds. In order to record spectra from samples of very small area, relatively high magnification is usually necessary (*5*). At present, the microspectrophotometer described here is not to be compared with these. Our instrument is portable in the sense that it can be easily assembled and used in the field. The maximum magnification employed to date is 500. At this magnification, spectra from areas of 2 μ^2 are easily obtained. Optical alignment is not critical, and the effects of stray light have been found to be negligible. No optical beam chopping is used, mainly because of the relatively long time constant of the photocell. Since the entire photosurface of the cell is exposed to the light beam, no effects due to varia-

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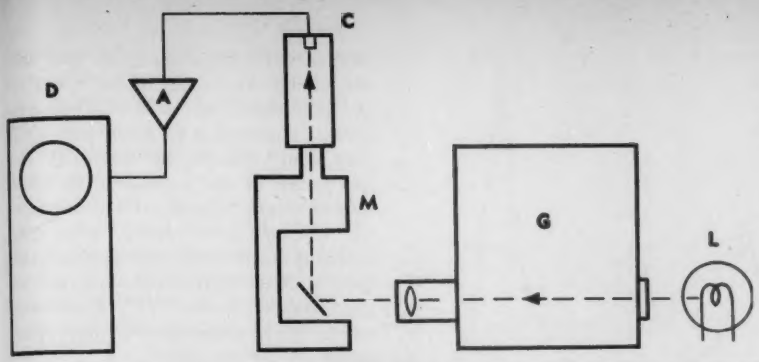
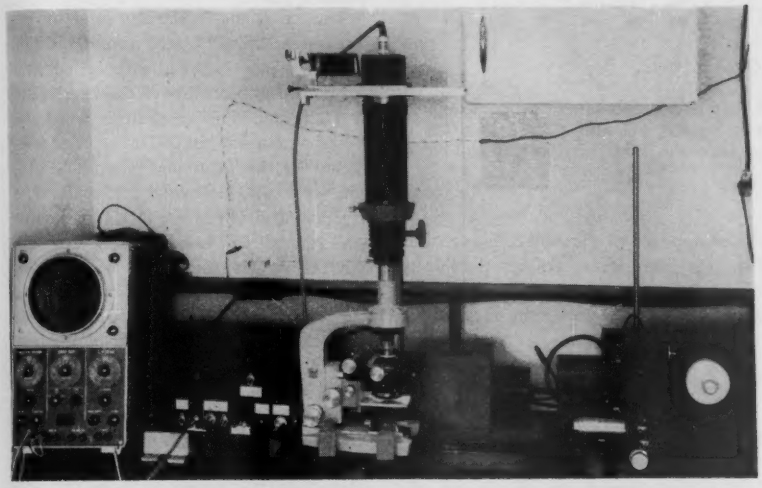




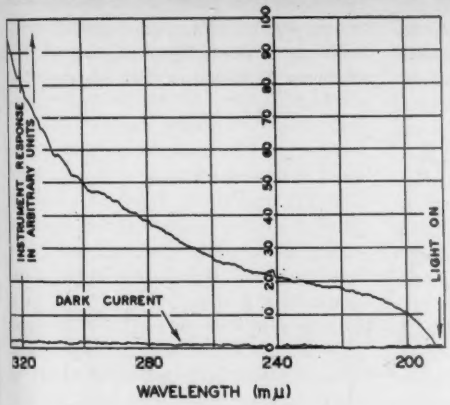
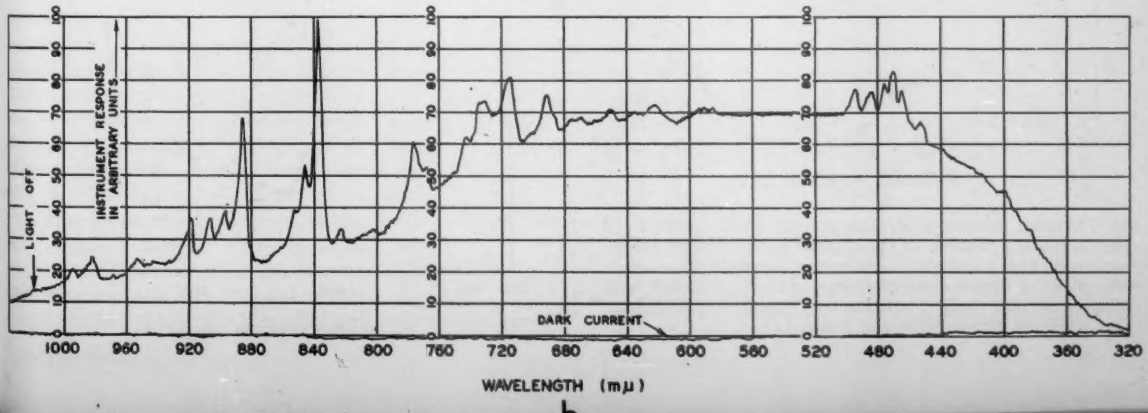


Fig. 1 (Above). Microspectrophotometer showing light source *(L)*, monochromator *(G)*, microscope *(M)*, photoconductive cell *(C)*, d-c amplifier *(A)*, and oscilloscope (D). (Bottom) The microspectrophotometer in use.

Fig. 2 (At left and below). Microspectrophotometer response as a function of the wavelength of the incident light (*a*) from 200 to 320 mμ and (*b*) from 320 to 1000 mμ, with reduced intensity of incident light.



tion in the sensitivity of the photosurface are observed. A simple resistance-capacitance filter is employed at the amplifier output, resulting in an instrumental time constant of 2 seconds.

The photocell output as a function of the intensity of the incident light was investigated by comparison with the output of an RCA 926 phototube calibrated in our laboratory. Linearity of photocell output within 2 percent with incident light intensity was observed except for very low light levels, which are not normally encountered with this instrument.

At present, the instrumental noise level is determined by the light source and the amplifier fluctuations rather than by the noise in the photocell. For the Soret band peak of a single human blood cell, the noise level was 2.5×10^{-3} optical density units at a wavelength setting of 420 mμ and an entering bandwidth of 2 mμ. Although the useful optical density range of the instrument depends upon the wavelength setting and the intensity of the incident light, data taken to date indicate an upper limit of 1.5 optical density units before serious inaccuracies occur.

The procedure for obtaining an absorption spectrum with the apparatus in its present form is relatively simple. The area of interest in the specimen is located on a marked ground-glass screen at the top of the apparatus. The photocell is then put in position, and the dark current is balanced out with bias voltage. At each desired wavelength setting, one reading is taken over the specimen and another over a reference area by moving the cell assembly from one area to the other. Before another reading is taken, the dark current level is checked and set to zero. The time required to determine a spectral curve depends upon the number of wavelength settings desired and the time constant of the photocell. For a 10-mμ interval over the range from 400 to 700 mμ, the time required is about 20 minutes.

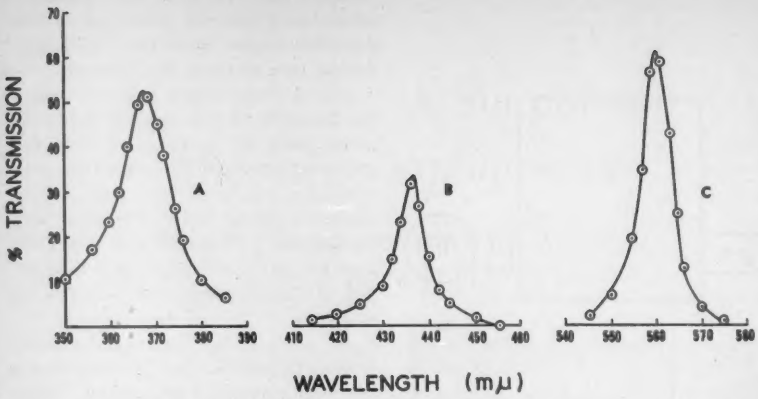


Fig. 3. Spectral response curves for three different interference filters with maxima at 368, 436, and 560 mμ, respectively. Filter *A* is Bausch & Lomb No. 33-78-36; *B* is Bausch & Lomb No. 33-78-43; *C* is Baird Associates No. 7-3470-3. Incident half-bandwidth, 2 mμ.

Because of the simplicity of the microspectrophotometer design, the demands made upon the operator are greater than those made by an automatically controlled instrument. For each specimen under investigation one must choose optimum values for the monochromator slit widths, which govern both the purity and the intensity of the light entering the system. In addition, one has a choice between critical or Köhler (even) illumination of the specimen. For critical illumination the image of the exit slit of the monochromator appears in the object plane, and the light intensity is greater than it is when the specimen is evenly illuminated. Both of the foregoing factors depend upon the choice of magnifying power.

Applications

This instrument was designed primarily to make relatively short *in situ* spectral analyses on pigment granules and photoreceptor structures—that is, chloroplasts, chromatophores, and the retinal rods and cones of the eye. Use of these structures, which in general contain pigments in relatively high concentration, reduces the sensitivity requirements of the instrument. In addition to determining spectral absorption, the instrument is ideally suited for scanning single cells (*7*) or small organisms at fixed wavelengths in order to geometrically locate cell constituents which have characteristic absorption peaks.

The complete spectral range of the instrument is illustrated graphically in Fig. 2, which shows the recorded output of the photocell over the range 200 to 1000 mμ. The recordings were obtained with a Varian G-10 recorder connected to the amplified photocell output, set for 50 millivolts full scale. The wavelength drum of the monochromator was turned by hand throughout the spectral ranges indicated. In Fig. 2*a*, the entrance half-bandwidth was 2.6 mμ and the incident light was used at full intensity. In Fig. 2*b*, the half-bandwidth was 2 mμ, and the intensity of the incident light was greatly reduced to keep the recorder pen on scale at the peaks. For wavelengths greater than 600 mμ, the second-order grating spectrum was filtered out. The series of response peaks around 460 mμ and in the region 800 to 1000 mμ is due to line spectra of the xenon arc light source. For both of the

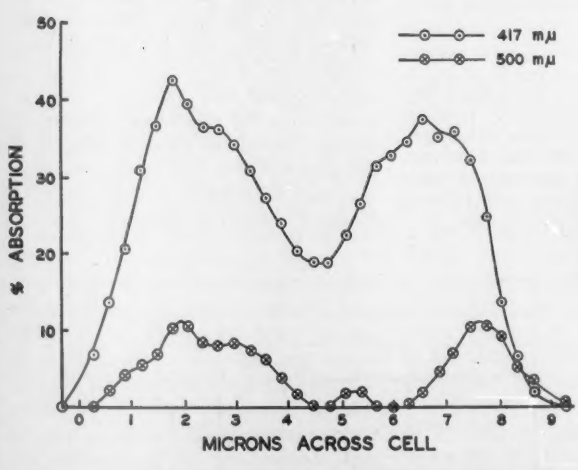
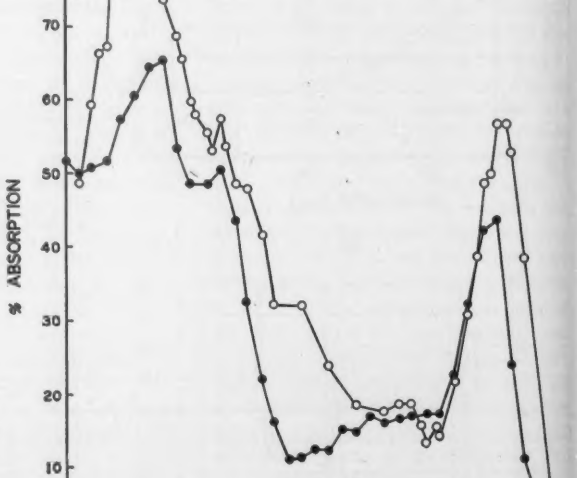


Fig. 4 (Above). Spectral absorption at fixed wavelengths of 417 and 500 mμ as a function of the distance across a single human blood cell. Fig. 5 (Right). Absorption spectrum of a single chloroplast of *Euglena gracilis* (open circles) compared with the spectrum of a single chloroplast of *Chlorella* (solid circles), taken from the data of Swift and Rasch (*1*).



response curves the microscope was focused on a blank quartz slide at a magnification of 175, representing a specimen area of 16 μ^2.

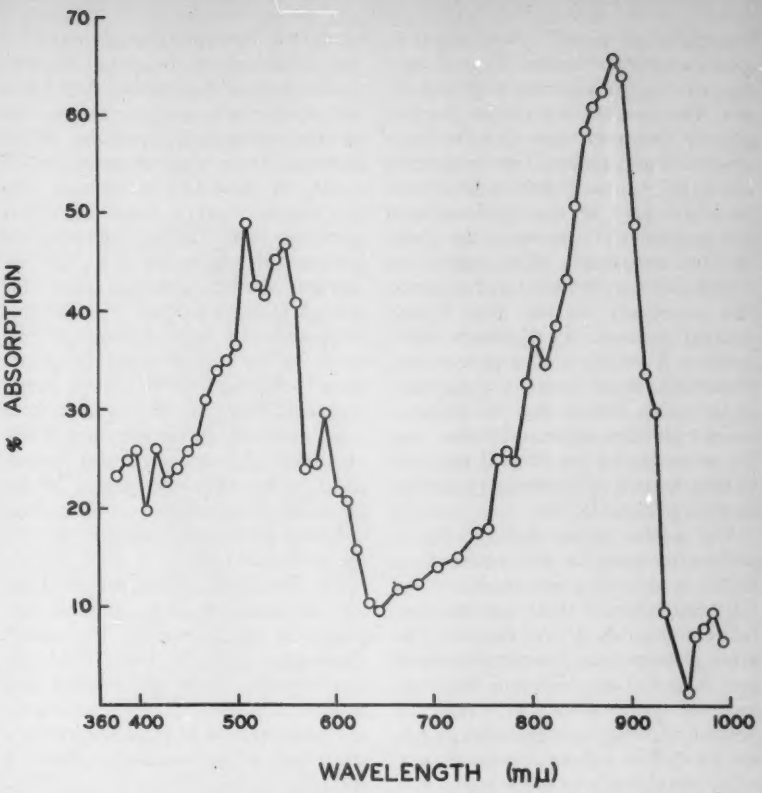
The performance of the microspectrophotometer has been checked with bandpass filters, line spectra, and materials with known absorption peaks. In Fig. 3 are plotted response curves for Bausch & Lomb interference filters Nos. 33-78-36 and 33-78-43 and for a Baird Associates interference filter No. 7-3470-3; the major peaks of these filters are at 368, 436, and 560 mμ, respectively. These absorption curves are in excellent agreement with those obtained with a Beckman model DK recording spectrophotometer for the same filters.

Absorption spectra (not shown) have been obtained from single human blood cells. These showed characteristic absorption peaks at 418, 538, and 578 mμ. In Fig. 4 are illustrated two transverse scans across a single human blood cell with wavelength settings of 417 and 500 mμ, respectively. The difference between the two curves is a rough indication of the hemoglobin distribution within the blood cell as a function of cell diameter. The specimen area under investigation was slightly less than 2 μ^2, and the results are in good agreement with published data (*7*, *8*).

Figure 5 shows the absorption spectrum in the visible region of a single chloroplast within the algal flagellate *Euglena gracilis* (open circles) compared with the specrum of a chloroplast from *Chlorella* (solid circles) taken from the data of Swift and Rasch (*1*). The average size of *Euglena gracilis* is 50 by 15 μ, and the green chloroplasts are on the order of 1 by 6 μ (*9*). The magnification was 250, representing a specimen area of 8 μ^2. The reference area was the clear region in the cytoplasm adjacent to the chloroplast. The major absorption peaks at 415 to 430 mμ and at 680 mμ are in agreement with the data for chlorophyll *A* in living algae (*10*), and the secondary peak at 480 mμ is due to the presence of carotenoids, which are known to be present in the chloroplasts (*10*). The absorption spectrum shown in Fig. 5 is also in good agreement with the spectrum for cell suspensions of *Euglena* obtained in our laboratory (*11*).

A suspension from a culture of the photosynthetic bacteria *Rhodospirillum rubrum* was placed on a microscope slide and scanned over the wavelength range 380 to 990 mμ. The bacteria from this culture were too small for individual spectra to be obtained, since they were less than 1 μ in diameter. The absorption spectrum from the microscope slide suspension is shown in Fig. 6. The major peak at 880 mμ and the small peak at 590 mμ are due to bacteriochlorophyll (*12*). The secondary peak in the region 500 to 550 mμ is due mainly to the bacterial carotenoid spirilloxanthin (*12*). The data were taken at a magnification of 250, representing a suspension area of 8 μ^2. The reference area was a clear region under the cover glass adjacent to the bacterial suspension.

The microspectrophotometer has also been used (*13*) to investigate the brightly colored oil globules found in the retina of birds, occurring mainly between the inner and outer segments of the cones (*14*). These colored globules are red, green, yellow, orange, and other, mixed, colors; they range from 3 to 5 μ in diameter, and their exact physiologi-



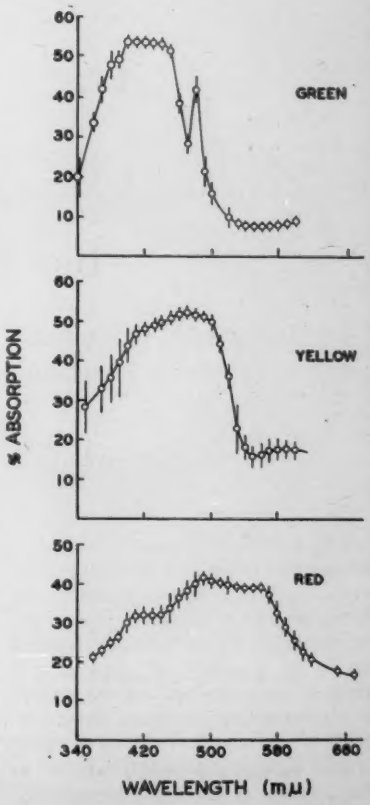


Fig. 6 (Top). Absorption spectrum of a sample of an "old" culture of aerobic *Rhodospirillum rubrum*. Fig. 7 (Bottom). Absorption spectra, measured *in situ* for red, yellow, and green globules within the chicken retina.

cal role is not known (*5*, *13*). Figure 7 shows absorption spectra for red, yellow, and green globules measured *in situ*. The vertical lines indicate the observed variability for each colored globule. These spectra were measured at a magnification of 500 through a specimen area of 2 μ^2. The reference area was immediately adjacent to the globules and contained a slight amount of retinal material. Spectra taken of globules completely isolated from retinal material indicated no significant error resulting from this procedure over the wavelength range under investigation. These results indicate that the different colored globules within the retina can act as bandpass color filters if they are suitably located in relation to a photosensitive pigment (*5*, *15*).

The spectral curves shown in Fig. 7 indicate the presence of carotenoids, a finding in agreement with the biochemical investigation of Wald and Zussman (*15*) on retinal extracts of chicken. The green globules have a major absorption peak near 420 mμ, indicating the presence of galloxanthin, a carotenoid isolated by Wald from the chicken retina (*16*). The yellow globules have a major absorption peak in the region 470 to 480 mμ. Absorption in this portion of the visible spectrum is typical for both xanthophylls and carotenes. Both lutein and zeaxanthin are present in the chicken retina (*15*), and the yellow globules are believed to be composed mainly of these two carotenoids. The red globules have a broad absorption maximum near 500 mμ, indicating the presence of astaxanthin (*15*). The absorption spectra obtained from the colored globules are not from purified compounds but from mixtures of pigments in the natural state. Therefore, some wavelength shifts toward longer wavelengths are to be expected from spectra reported in the literature. These pigmented globules were also investigated in the ultraviolet region of the spectrum. The presence of lipids was indicated by strong absorption at 310 mμ and below (*13*).

The illustrated spectra described are only an indication of the possible usefulness of the instrument. The microspectrophotometer is well suited for study of the effects of chemical and physical environment on the synthesis and concentration of pigments within a single cell or of organelles within a cell (*17*).

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Electromagnetic Blood Flow Meters

Implantable flow transducers facilitate circulatory studies in conscious and free-moving animals.

Alexander Kolin

The interest in a method for determination of blood flow goes beyond the need for such methods in studies of hemodynamics. The wider scope of the potentialities of an effective method lies in the possibility of using it in a general way as an index of the activity of a great variety of organs whose performance is normally studied by quite diverse methods specifically adapted to the function of the organ in question. The rate of blood supply to an organ is a determining factor in regulation of the supply of oxygen, hormones, and nutrient materials. It similarly determines the rate of removal of metabolic products. The blood flow through an organ, when correlated with its rate of activity, could thus be used to follow variations in the organ's activity in response to a variety of stimuli and inhibiting factors.

Ideally, the method of blood-flow determination should permit continuous recording of blood flow in intact undisplaced blood vessels of conscious, freely moving animals. The application of the principle of electromagnetic induction to measurement of blood flow (*1–3*) resulted in a method which, in subsequent modifications, made it possible to record blood flow by means of nonirritating implanted measuring devices (*4–7*). The method is based on the induction of an electromotive force in a fluid flowing transversely through a homogeneous magnetic field. In the case of a circular conduit and axially symmetrical flow, the induced electromotive force is a linear function of the average fluid discharge. In the case of a conductive conduit, the electrical signal can be picked up without making contact with the fluid by establishing contact with two points on the outside wall of the conduit situated at the two ends of a diameter perpendicular to the magnetic field. This configuration is illustrated in Fig. 1.

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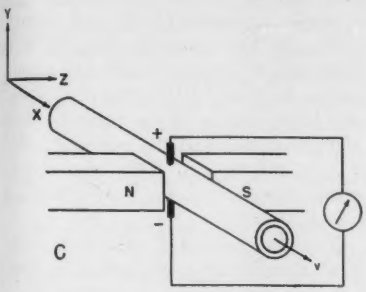
Modifications of the Electromagnetic Flow Meter

The early form of this method was based on use of a constant magnetic field (*1–3*). This required employment of cumbersome nonpolarizable electrodes. The introduction of an alternating magnetic field (*3*, *8*) made it possible to use ordinary metal electrodes. This advantage, however, was not gained without sacrifice. Whereas, with a constant magnetic field it is possible to establish a base line corresponding to zero flow by switching off the magnetic field, it is no longer possible to do so without special adjustment in the case of an alternating magnetic field (*9*). A successful attempt was made to combine the advantages of the constant magnetic field with those of the alternating magnetic field by energizing the magnet with a square wave current (*10*). This, however, has been accomplished only through great complexity of circuit design.

The system that I currently prefer utilizes magnets energized by a sinusoidal current and uses phase-sensitive detectors to separate the flow signal from the flow-independent signal induced by transformer action in the input lead circuit (*7*). Phase-sensitive detection was initially based on optical and photoelectric means (*4*, *8*, *11*). An electronic method of sampling the sine-wave signal derived from an electromagnetic flow meter was suggested for the first time by W. J. James (*12*). The phase-sensitive amplifier used in my laboratory (*7*) provides amplification of signals of less than 1 microvolt (μv) at a noise level of less than 0.2 μv. This high sensitivity makes it possible to de-



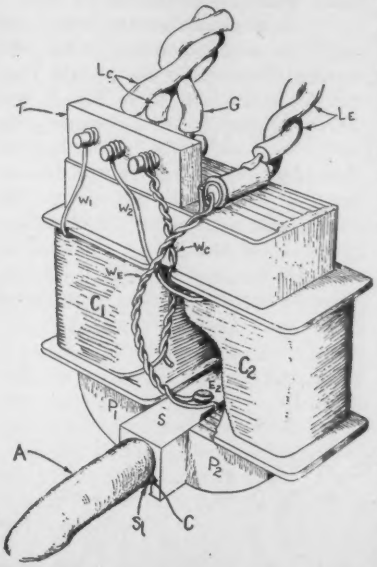


Fig. 1 (left). Configuration of flow (v), magnetic field (magnet poles, *N*, *S*), and pickup electrodes (+, −) in an electromagnetic flow meter. Fig. 2 (right). Skeleton of an electromagnetic blood flow meter with inserted artery (*A*). *S*, sleeve; *Sl*, slit for insertion of artery; *C*, sleeve channel; E_2, one of the pickup electrodes which contact the outer wall of the artery; P_1 and P_2, pole pieces of the magnet; C_1 and C_2, magnet coils; L_E and W_E, electrode leads; *G*, ground lead; *T*, terminal board.

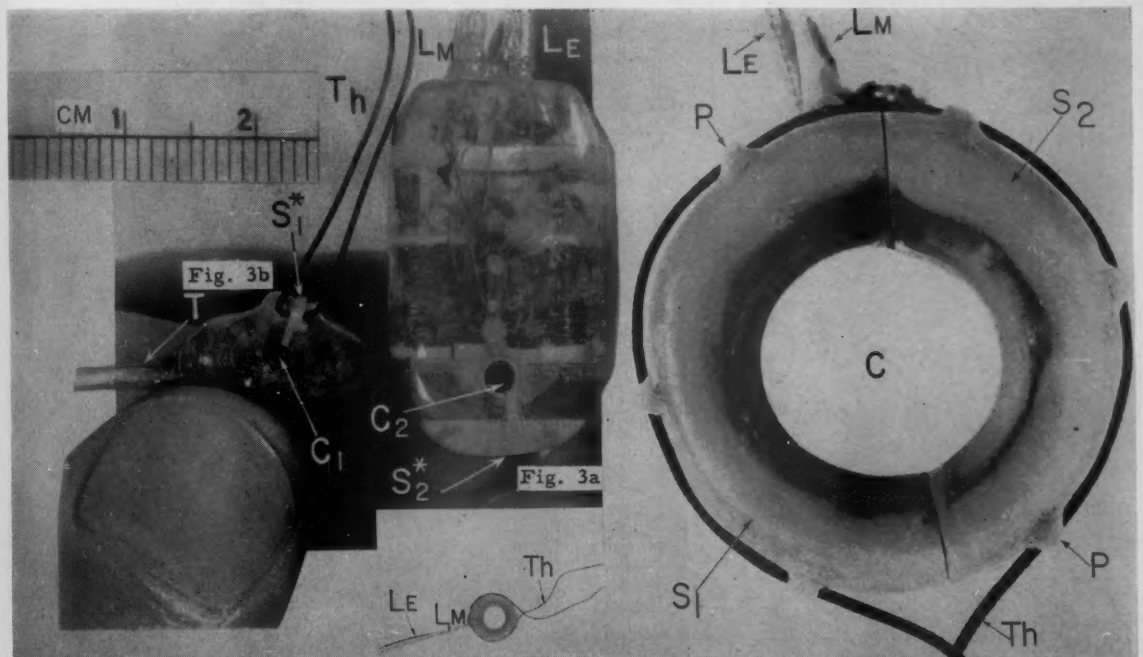


Fig. 3. Implantable electromagnetic blood flow meters. (a) The original implantable "miniature" flow meter for a 2-mm artery. C_2, artery channel; S^*_2, shutter preventing the artery from slipping out; L_M, magnet leads; L_E, electrode leads. (b) Subminiature flow meter for a 1.5-mm artery. *T*, tubing containing the leads; C_1, artery channel; S^*_1, shutter; *Th*, thread. (c) Coreless flow meter for a 15-mm artery. This unit has no hinges (compare Fig. 6). The two halves, S_1 and S_2, are tied together by the thread *Th*. *P*, thread holes; *C*, artery channel; L_E, electrode leads; L_M, magnet leads. (d) Flow meter shown in Fig. 3c reduced to caliber of Fig. 3b. The smallness of the space occupied by the magnet as compared to Fig. 3b is conspicuous in this design. [From Kolin and Kado (*7*)]

sign the very small implantable flow meters described below.

The selection of the frequency of the alternating magnetic field depends on several factors. If the details of the flow throughout the cardiac cycle are to be studied, a high-frequency carrier of adequate bandwidth is essential. The selection of a high frequency is also of advantage in minimizing electrode polarization. On the other hand, the spurious flow-independent signals which are introduced into the electrode circuit from the magnet circuit by electromagnetic induction (transformer action) and by electrostatic coupling increase in proportion to the frequency. The pickup due to galvanic coupling (current leakage from the magnetic power source into the electrode circuit due to poor insulation) is independent of frequency.

The foregoing survey classifies the modes of implementation of the electromagnetic flow-meter principle according to the time function of the magnetic field used. The mode of application of the magnetic field and of the electrodes provides an additional important criterion of classification. We can distinguish between the following main modes of application.

1) In the canula-type flow meter (*13*), a short dielectric tube with sensing electrodes is placed in a magnetic field, as shown in Fig. 1, and firmly attached to the flow-meter magnet. The blood vessel is cut, and the flow-meter "canula" is inserted between the two ends of the cut artery. The blood vessel is exteriorized, and the animal must be anesthetized and heparinized. The use of this modification is indicated where the flows to be measured are very minute, so that the magnets which are used with the modifications described below are not intense enough to provide the needed sensitivity.

2) In the flow meter for intact exteriorized arteries (*1–3, 8*), the position of the blood vessel and the state of the animal are the same as in the preceding modification except that the blood vessel is not cut. It is, rather, inserted into a sleeve *S* similar to the one shown in Fig. 2. The sleeve is equipped with electrodes E_1 and E_2, which contact the blood-vessel wall at the end of a diameter perpendicular to the magnetic field maintained between the poles (P_1 and P_2) of the magnet. This approach is made obsolete by the two following modifications.

3) The implanted electromagnetic flow transducer is, in principle, the same as the flow meter described in

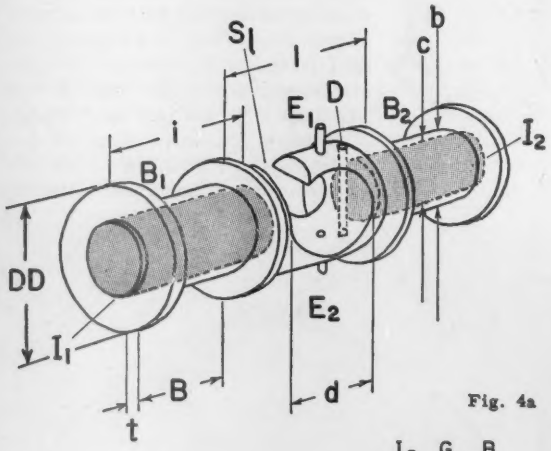


Fig. 4a

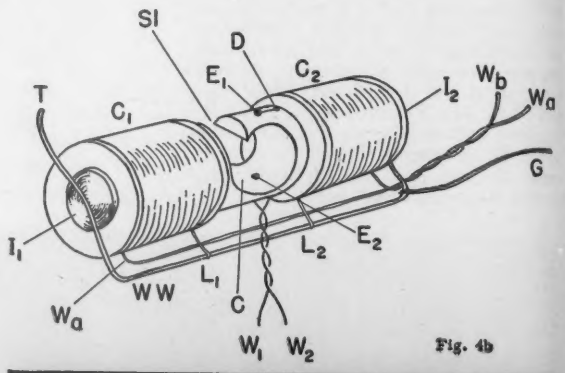


Fig. 4b

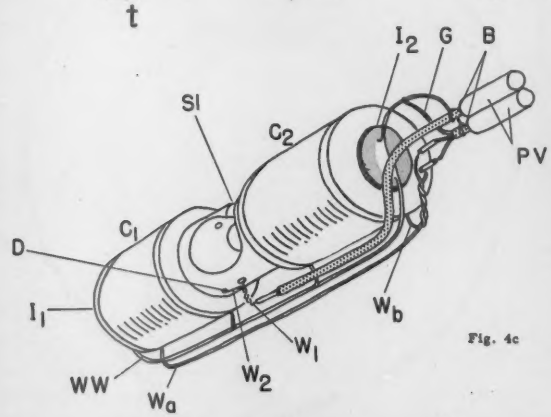


Fig. 4c

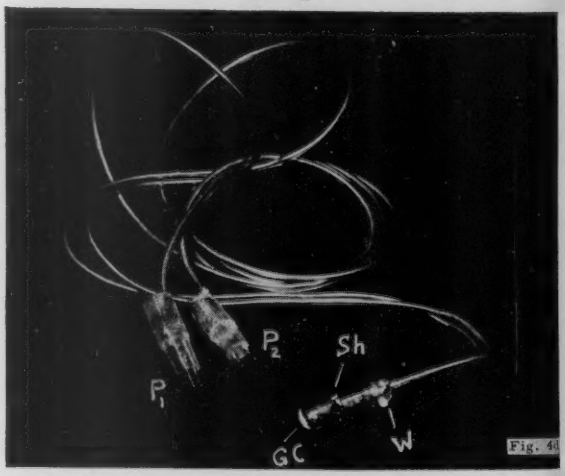


Fig. 4d

Fig. 4. Implantable subminiature electromagnetic flow meter. (a) Sleeve and bobbins B_1 and B_2, for the subminiature blood flow meter. *Sl*, slit; E_1 and E_2, electrodes; *D*, channel for electrode wire; I_1 and I_2, iron cores. The other letters refer to letters in Table 1. (b) Skeleton of subminiature flow meter. E_1 and E_2, electrodes; *Sl*, slit; *D*, electrode wire channel; W_1 and W_2, electrode wires; C_1 and C_2 magnet coils; *T*, grounding "tail"; W_a and W_b, magnet leads; *G*, ground lead; *WW*, wire connecting the iron core ends; L_1 and L_2, wires connecting the coils in series; *C*, artery channel. (c) Insulation and shielding scheme of the subminiature flow meter. *Sl*, Slot; W_2, electrode wire; W_{1a}, electrode lead wires; C_1 and C_2, magnet coils; I_1 and I_2, iron cores; *B*, grounded wire braid; *G*, ground lead; *PV*, polyvinyl chloride tubing; W_a and W_b, coil lead wires; *WW*, wire joining cores I_1 and I_2. (d) Compression-molded subminiature flow meter. The diameter of the sleeve channel is 3 mm. P_1 and P_2, plugs; *GC*, gold cap; *Sh*, Teflon shutter, *W*, Teflon wing (a rod inserted into a sliding bed cast within the TDM body).

modification 2. The modification consists of minimizing the size of the magnet so as to make the flow meter implantable, and of casting the magnet and sleeve into an integral unit. The plastic material secures good electrical insulation between the magnet coils and the electrode circuit. This is very important, since the slightest electrical leakage will give rise to an excessively large spurious signal at zero flow.

The development of high-gain, low-noise amplifiers made it possible to diminish the strength of the magnetic field to a point where the implantable flow meters are small enough to represent a negligible source of mechanical irritation.

The advantage of this modification lies in the possibility of permitting the animal to recover after the implantation of the flow meter and of carrying out observations of blood flow on conscious, essentially normal, and nearly freely moving animals. The same kind of transducer can also be used for determination of blood flow in human subjects during surgery.

4) In spite of the small size of the flow meters of modification 3, there are occasions when it is advisable to go even further in miniaturizing the implant. At the same time, it is desirable to simplify the design of the miniaturized flow transducers, since the fabrication of extremely small transducers consisting of a miniature electromagnet with slotted sleeve, shutter, coils, shields, and so on, is a very complex and delicate job.

Both the simplification and the miniaturization of the implant can be achieved by implanting only the sleeve with pickup electrodes and establishing the magnetic field by means of coils external to the animal body (*4, 14*).

This method possesses the disadvantage of allowing less freedom of movement to the animal, but this is compensated for by the advantage that an implant of smallest possible size, and of the utmost simplicity of construction, can be used. In addition, many simultaneous implants can be used, for simultaneous recording of blood flow in different blood vessels, with a single, large coil to produce the external field.

In this article I have concentrated on discussion of the last two modifications, which, in turn, can be implemented in different ways.

Implanted Blood Flow Meter with Internal Magnet

The flow meter shown in Fig. 2 is actually the skeleton of an improved design (*6*) of a miniature transducer developed for implantation (*5*). Figure 3 shows the evolution of the implantable flow meter incorporating a magnet. Figure 3a shows the original design for a 2-mm artery, and Figure 3b shows, for comparison, the subminiature design of neighboring caliber (1.5 mm) developed subsequently (*6, 7*). Figure 3c shows a flow meter with a coreless magnet, developed for large arteries, and Fig. 3d shows its channel reduced to the same size as that of Fig. 3b. The great reduction in the size of the implant as compared with the channel diameter is quite apparent. The description in this section is limited to the most recent designs of the types shown in Figs. 3b and 3c, which I shall designate the "linear core" unit and the "coreless" unit, respectively. The former design is most effective and convenient for arteries up to about 4 mm in diameter, whereas the second design is used for arteries over 5 mm in diameter.

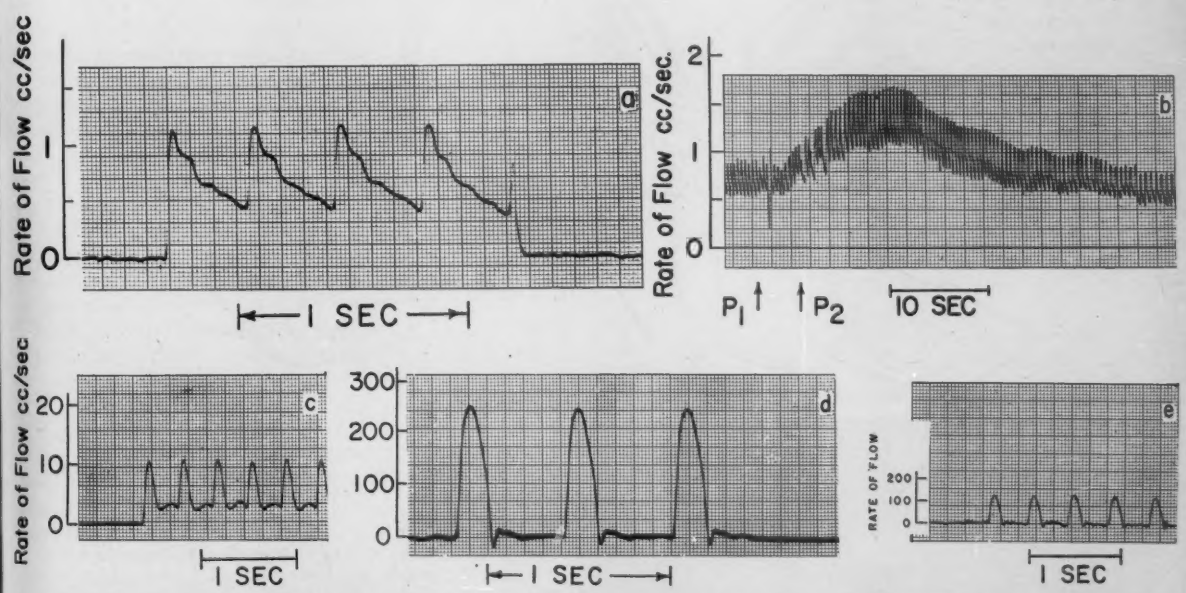


Fig. 5. Blood-flow records obtained (mainly in the course of as yet unpublished studies with L. W. Roth) with different arteries and with different types of implantable flow meters. The ordinate is rate of flow in cubic centimeters per second. The horizontal sections at the left or right ends of the records are base lines obtained by switching off the magnet. (a, b) Blood flow in a conscious cat's carotid artery (1.5 mm in diameter) recorded with a subminiature electromagnetic flow meter; (a) flow contour throughout the cardiac cycle taken at fast recording paper speed; (b), effect of exposure of a conscious cat to ammonia vapors (between the marks P_1 and P_2), taken at slow speed of recording paper. (c) Blood flow in the carotid artery (3 mm in diameter) of a conscious dog, recorded with a transducer of the type shown in Fig. 4d. (d) Record of blood flow in the ascending aorta of a conscious dog, made with a coreless flow meter of the type shown in Fig. 6. (e) Blood flow in the ascending aorta of a conscious dog, recorded by means of the external-field method; a strapped-on magnet (shown in the photograph in Fig. 8) was used, and there was no compensating coil.

"Linear Core" Flow Meter

Figure 4 shows the alignment of the coils (C_1 and C_2), iron cores I_1 and I_2, and sleeve S in the "linear core" flow meter type of transducer (*15*). Figure 4a shows the Lucite form, which can be cast or machined from a Lucite rod. The rod is turned in a lathe so as to produce two bobbins, B_1 and B_2, on which the coil wires are to be wound. The iron cores I_1 and I_2 slip tightly into the bobbins. They should, preferably, be made of laminated material, iron powder, or ferrite, but solid iron cores can be used without excessive heating for units accommodating arteries below 2.5 mm in diameter. Channel C (Fig. 4b) is drilled at right angles to the axis of the Lucite cylinder from which the Lucite skeleton shown in Fig. 4a is machined. The artery is slipped into this channel through the slit *Sl*. A very narrow channel (½ mm) is drilled *precisely* at right angles to channel C. The gold electrodes E_1 and E_2 are introduced through this channel. Their ends are filed flush with the walls of channel C. The exact perpendicularity of the electrode channel to channel C is essential to minimize the potential difference which would arise between electrodes E_1 and E_2 due to currents parallel to the axis of channel C.

A narrow channel D, about 0.13 mm in diameter, between channel C and the end of the iron core I_2, is drilled in the plane passing through the electrodes and the axis of I_1 and I_2. The lead wire W_1 (compare Fig. 4b) connected to E_1 passes through it to join the lead W_2, with which it is twisted (gauge No. 39 wires with heavy Teflon insulation are used for adequate breaking strength).

Figure 4b shows a perspective drawing of the flow-meter skeleton with the coils C_1 and C_2 wound onto the bobbins B_1 and B_2 of Fig. 4a. Wires L_1 and L_2 connect the two coils in series through wire WW, which joins the ends of the cores I_1 and I_2 to each other and to the ground lead G. The "tail" is allowed to emerge to the surface of the flow meter after it has been cast in plastic material (see below). The emerging end of the "tail" is pressed flat against the plastic enclosure of the flow meter after completion of the cast and is painted, as is the adjacent surface at the end of the unit, with silver paint (Du Pont No. 4922). This silver-painted spot is then silver-plated in a potassium silver cyanide solution at 30 ma/cm² for 30 minutes and subsequently gold-plated in a potassium gold cyanide solution at 5 ma/cm² for ½ hour. The gold cap thus formed at the end of the flow meter grounds the animal.

Figure 4c shows the shielding and insulating scheme of the leads. The electrode leads W_1 and W_2 are shielded by the grounded wire braid B, which is enclosed in a polyvinyl chloride tubing PV. The coil leads W_a and W_b and the ground lead G are similarly enclosed in polyvinyl chloride tubing. The proper performance and durability of the transducer depends on achieving a very good bond between the polyvinyl chlo-

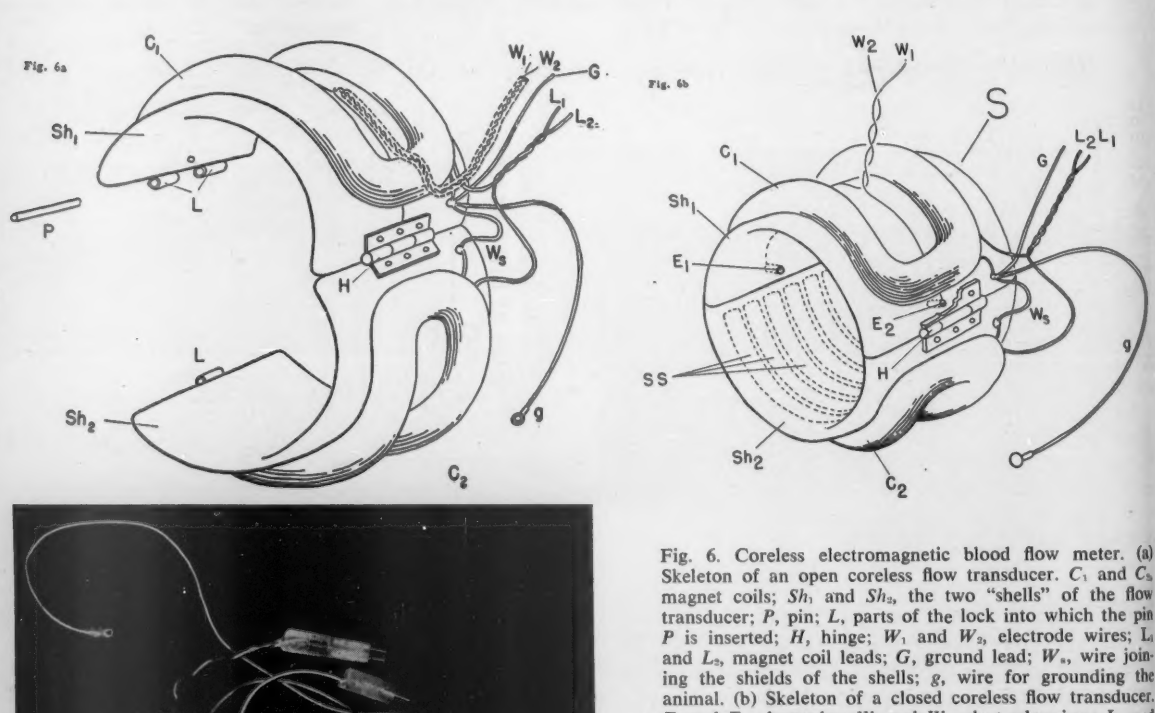


Fig. 6. Coreless electromagnetic blood flow meter. (a) Skeleton of an open coreless flow transducer. C_1 and C_2, magnet coils; Sh_1 and Sh_2, the two "shells" of the flow transducer; P, pin; L, parts of the lock into which the pin P is inserted; H, hinge; W_1 and W_2, electrode wires; L_1 and L_2, magnet coil leads; G, ground lead; W_s, wire joining the shields of the shells; g, wire for grounding the animal. (b) Skeleton of a closed coreless flow transducer. E_1 and E_2, electrodes; W_1 and W_2, electrode wires; L_1 and L_2, magnet lead wires; W_s, wire connecting the coils in series and joining the shields Sh_1 and Sh_2; C_1 and C_2, magnet coils; SS, shielding "ribs"; G, ground lead; g, wire for grounding the animal; S, the artery sleeve of the flow transducer. (c) View of a finished flow transducer for a 12-mm artery. H, hinge; L, pin lock.

ride tubing and the solid plastic. This is achieved by presoaking the ends of the tubing in the monomer of the "Teets denture material" (TDM) from which the plastic body of the flow meter is made for about ½ hour and by applying the polymerizing paste of TDM to the tubing before its surface has dried noticeably. Instead of being presoaked in the monomer, the tubing may be covered with the plastic cement "Dab" (Hollingshead Corp., Camden, N.J.). The best bond is obtained with compression molding of the transducer. The tube becomes very soft at the molding temperature of about 150°C and forms a tight bond with the Lucite which is injected under pressure into the hot mold.

Figure 4d is a photograph of the finished compression-molded flow meter for an artery 3 mm in diameter.

In Fig. 4d, *Sh* is a Teflon shutter which is cast in the plastic material so as to create its own sliding bed. It is removed to admit the artery through the slit into channel *C* and is then reinserted, to prevent the artery from slipping out. A black thread is inserted through a small hole at the end of *Sh* to facilitate handling of the shutter. *W* is a Teflon "wing" which can be inserted into a special gliding bed produced in much the same way that the bed for shutter *Sh* is produced. It is provided with small holes at its ends (marked by black threads) through which it can be sewn onto tissues to stabilize the orientation of the flow meter maintaining the axis of channel *C* parallel to the artery. Failure to maintain this orientation may result in occlusion of the artery by twisting of the flow meter.

Table 1 gives a recommended set of dimensions for flow meters, covering the range of artery diameters from 1 to 4 mm. For diameters above 5 mm it is more advantageous to use flow meters of the coreless design described below. The dimensions are arbitrary, being primarily determined by convenience of standardization of construction. The number of turns of gauge No. 36 Teflon-insulated copper wire is kept constant at 230 turns per coil. A current of 200 ma is used in continuous operation, yielding a magnetic field of 104 gauss, for example, in the case of the 3-mm-channel transducer. The flow signal amplitude V_o, in microvolts, is given by the following expression:

$$V_o = 10^{-3} \cdot {}_oDv \qquad (1).$$

Table 1. A recommended set of dimensions for flow meters of different calibre, covering the range of artery diameters from 1 to 4 millimeters. See Fig. 4a for parts designated by letters in column heads.

d (mm)	*B* (mm)	*l* (mm)	*c* (mm)	*b* (mm)	*i* (mm)	*DD* (mm)	*t* (mm)	No. of turns
1	3	2.5	1	2	4	6.5	0.5	230
1.5	3	3	1.5	2.5	4	6.5	0.5	230
2	3.5	3.5	2	3	4.5	6.5	0.5	230
3	5	4.5	3	4	6	6.5	0.5	230
4	8	5.5	4	5	9	6.5	0.5	230

where B_o is the magnetic field amplitude, D is the channel diameter, and v is the average blood velocity. For a linear velocity of 30 cm/sec [that is, discharge of $v=(\pi/4)\ D^2 \cong 2.1$ cm³/sec], we thus obtain the flow signal amplitude $V_o=9.4\ {}_\mu v$. This can be easily measured with a phase-sensitive amplifying system (*7*, *16*). Figures 5a and 5b show records taken with a unit of this type applied to a cat's carotid artery 1.5 mm in diameter, and Fig. 5c shows a record taken with a unit applied to a dog's carotid artery 3 mm in diameter.

The precision of the alignment of the electrode channels at right angles to channel *C* and wire channel *D* for Fig. 4a within the plane defined by the intersecting axis of the cores I_1 and I_2 and the electrode channel axis is very important to minimize the spurious signal induced at zero flow. When this signal

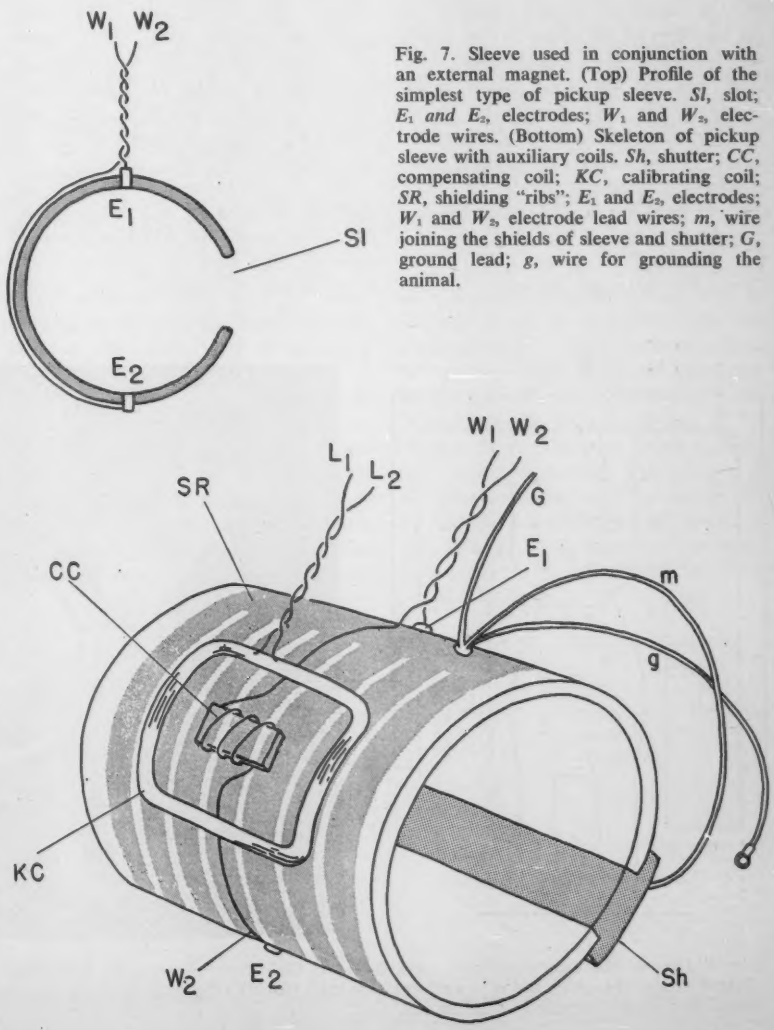


Fig. 7. Sleeve used in conjunction with an external magnet. (Top) Profile of the simplest type of pickup sleeve. *Sl*, slot; E_1 *and* E_2, electrodes; W_1 and W_2, electrode wires. (Bottom) Skeleton of pickup sleeve with auxiliary coils. *Sh*, shutter; *CC*, compensating coil; *KC*, calibrating coil; *SR*, shielding "ribs"; E_1 and E_2, electrodes; W_1 and W_2, electrode lead wires; *m*, wire joining the shields of sleeve and shutter; *G*, ground lead; *g*, wire for grounding the animal.

is small enough, it is ignored by the phase-sensitive recording system, and the base line for zero flow can be ascertained by switching off the magnet current.

Coreless Flow Meter

The large blood flow in the major arteries greatly simplifies the task of measuring flow in them. For example, a magnetic field of only 10 gauss is needed to obtain a 10-mv flow signal from an artery 2 cm in diameter carrying a flow of average linear velocity 50 cm/sec. This signal can be very easily recorded with a phase-sensitive amplifier (*7*). The implanted magnet can thus merely consist of air-core coils of relatively few turns. This greatly reduces the size of the implant, as may be seen from Figs. 3c, 3d, and 6a. The size of the air core magnet relative to the diameter of the artery is very much less than that of a subminiature iron core unit for the same blood vessel (compare Fig. 3d). Figure 6a shows the skeleton of such a flow transducer. C_1 and C_2 are the two coils generating the magnetic field. They are bent to conform to the shape of the cylindrical sleeve *S* (see Fig. 6b) and are cemented in place with TDM. They are connected in series by the wire W_2, which is grounded through the lead *G*. The current is supplied to the coils through the leads L_1 and L_2.

For an artery 15 mm in diameter, for instance, two coils of 50 turns each of gauge No. 29 Teflon insulated wire are used. A current of 1 amp, passed at continuous operation, yields a mean field of 28 gauss. For arteries of different sizes the same number of turns (50 turns per coil) is maintained, and the same current is used. It is desirable to increase the field intensity as the diameter of the artery decreases.

Wires W_1 and W_2 (gauge No. 39 wires with heavy Teflon insulation) are connected to electrodes E_1 and E_2 (see Fig. 6b), which lie in a plane perpendicular to the axis of the cylindrical sleeve channel. The wires are twisted to minimize pickup due to electromagnetic induction. Both electrodes and one coil (C_1) are fixed to one "shell," Sh_1, of the unit. The other, somewhat smaller, shell (Sh_2) carries the second coil C_2. The two shells are connected by a hinge *H*. Thus the unit can be opened to insert an artery and locked by the pin *P* shown in Fig. 6a after closing (Fig. 6b).

The sleeve formed by closing the shells is shielded by a laminated, riblike, silver shield, *SS*, which is grounded through connection to W_2. This shield is produced by painting the sleeve, prior to application of the coils, with silver paint (see above), scratching the silver paint to produce the riblike laminations (shown in Fig. 6b only on one shell), and silver-plating the "ribs" thus obtained. The shields of the two shells are grounded and joined by wire W_2. It is important not to cover too much of the surface with silver, in order to retain enough Lucite area for good adherence of the TDM, with which the unit is finally covered. The wires are shielded with a wire braid and insulated with polyvinyl chloride tubing in a way similar to that described above for the subminiature units. The lead wires are bent toward the sleeve and buried in TDM (after presoaking in TDM monomer). Wire *g* is connected to *G* and serves to ground the animal. Its bare end consists of a small gold ring, which is sewn onto an animal tissue that is a good conductor.

Figure 6c shows a 12-mm flow meter of this type. Before the hinge is attached by TDM to the two parts of the transducer, it is filled with a loose cotton plug soaked in normal saline. The two "shells" are then moved axially relative to each other until the "transformer electromotive force" recorded by the amplifying system has been reduced to zero. With this configuration fixed, hinge *H* and the lock *L* are attached to the "shells" by means of

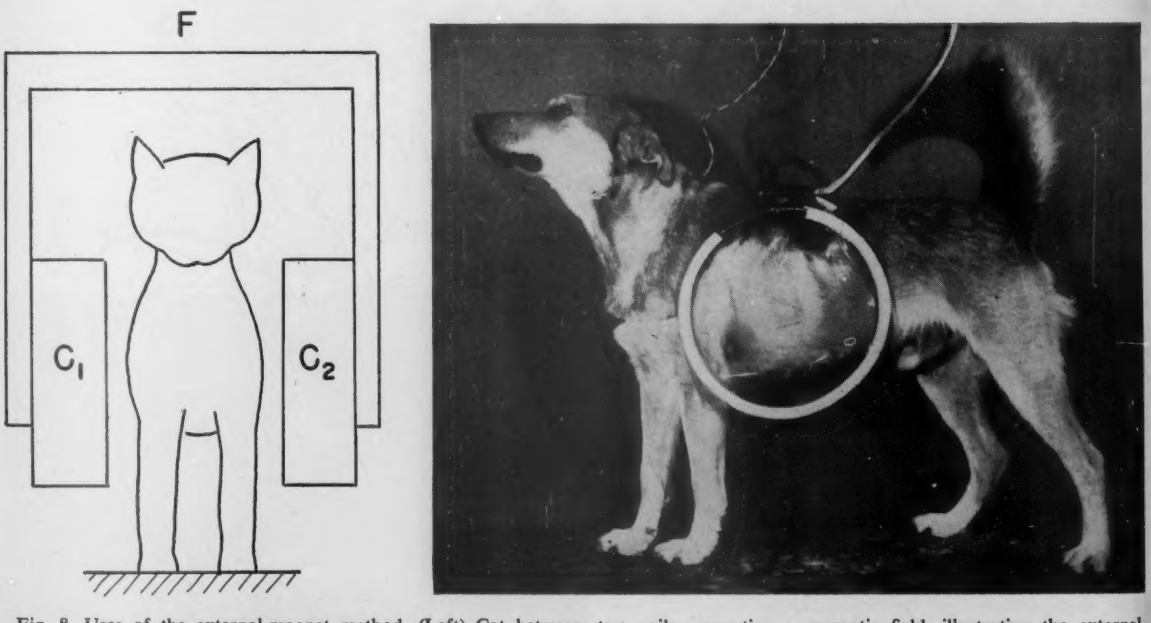


Fig. 8. Uses of the external-magnet method. (Left) Cat between two coils generating a magnetic field, illustrating the external-magnet method based on use of a stationary magnet. (Right) Dog with strapped-on coils, illustrating the external-magnet method based on a magnet attached to the animal.

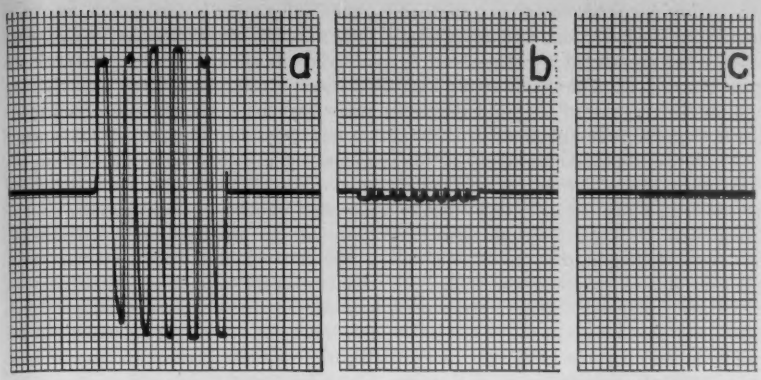


Fig. 9. Records showing the effectiveness of eliminating the transformer electromotive force in the external-magnet method by the use of a compensating coil and by means of a phase-sensitive detector (see text).

TDM. This assures a zero reading at zero flow.

Figure 5d shows a recording of cardiac output taken with a unit of this type applied to a dog's ascending aorta (10 mm in diameter).

External Magnet Method

As can be seen from Fig. 7 (top), the implant required for the external-field method is very much simpler and smaller than the flow transducers described in the preceding section. The principal part of the implant is the pair of electrodes E_1 and E_2, which are embedded in the thin Lucite sleeve. Wire W_2 connected to E_2 runs through a groove in the central plane of the sleeve which passes through the electrode axis E_1E_2. *Sl* is the slit through which the artery is inserted. *Sh* (Fig. 7, bottom) is a shutter which closes *Sl* to prevent the artery from slipping out. Wires W_1 and W_2 are shielded and insulated, as in previous designs. The magnetic field is established by an external magnet, as shown in Fig. 8 (left). For large gaps, such as the one shown in this figure, the gain in field strength through the use of an iron core becomes relatively small, and it is more advantageous to use a somewhat weaker but lighter air-core magnet. A pair of Helmholtz coils 30 cm in radius, of 300 turns per coil, carrying a current of 10 amp, will produce a field of about 100 gauss at the center between the coils. This field is 10 times as strong as the required field for measurement of flow in the major arteries, such as the aorta, and of adequate strength for flow measurements in smaller arteries of the order of magnitude of 1 mm in diameter. Due to the penetration of a large portion of the animal's body by the magnetic field, sleeves can be implanted about many relatively widely dispersed arteries for simultaneous measurements. In cases where the implants are far apart, consecutive measurements are made possible by moving the desired region of the animal's body into the magnetic field.

The stationary coil of Fig. 8 (left) requires immobilization of the animal during the recording of blood flow. This can be avoided by making the coil sufficiently light to be attached to the animal, as shown in Fig. 8 (right). This approach combines the advantage of freedom of motion achieved by the method described in the previous section with the advantages of the smallness and simplicity of the implant shown in Figs. 3c and 3b. The disadvantage lies in the necessity of strapping a coil of about 10 percent of the animal's weight onto the animal.

The main experimental difficulty encountered in this approach lies in the need to eliminate the flow-independent transformer electromotive force induced in the electrode lead wire loops. In principle, this can be done by positioning the animal in the magnetic field so as to reduce to zero the field component parallel to the sleeve axis. In practice, due to the animal's unavoidable movements, this ideal condition cannot be maintained. This problem can be solved, however, by use of a compensating coil (*4*) in series with one axis parallel to the sleeve axis and of the electrode leads, placed with its wound so as to introduce into the electrode circuit an electromotive force of opposite phase and equal magnitude to the transformer electromotive force. Figure 9 shows the effectiveness of this device. In Fig. 9a may be seen a record of the fluctuating signal delivered in the absence of a compensating coil by the electrode leads to the amplifier, due to angular oscillation of the sleeve over an angle of 180°. Figure 9b shows

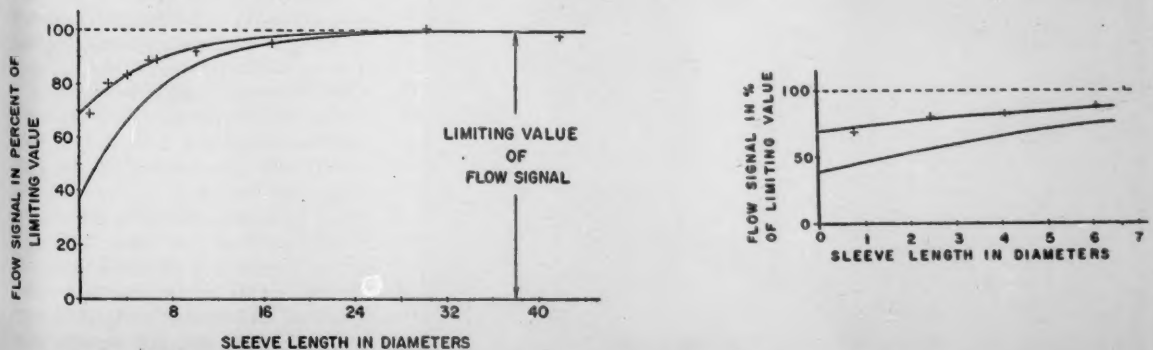


Fig. 10. (Left) Flow signal (in percentage of limiting value) (ordinate) as a function of sleeve length (abscissa). (Right) Enlarged-scale plot of the neighborhood of the origin.

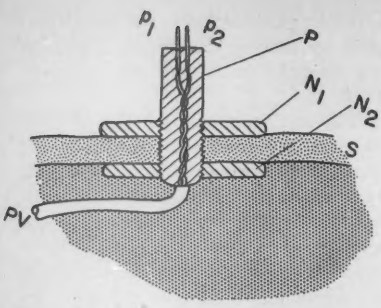


Fig. 11. Method of conveying the flow-meter leads through the animal's skin. P, threaded plug (cast from TDM); P_1 and P_2, contact pins; N_1 and N_2, nylon nuts; S, skin of the animal; PV, polyvinyl chloride tubing containing the lead wires.

a record obtained under the same condition with the compensating coil in the circuit. These records were obtained by deliberately phasing the phase-sensitive detector so as to reject the flow signal and to select the quadrature signal. By phasing the sensing circuit properly for rejection of the quadrature signal, the disturbance can be almost completely eliminated, as shown in Fig. 9c.

Figure 7 (bottom) shows the modification of the sleeve design to include the compensating coil CC. This coil is obtained by winding the appropriate number of turns of the lead wire W_2 about a coil form. W_2 is then twisted with W_1 into a single double lead W_1W_2. Coil CC is insulated by a layer of TDM, and the outside of the sleeve and of the shutter are gold-plated, as described in the previous section, and their gold shields are connected by wire m to a ground wire G. The bare gold-plated end of G is sutured to a conductive tissue to ground the animal.

A change in the orientation of the flow-meter sleeve introduces a change in the sensitivity of the flow meter. Component B of the magnetic field effective in inducing the flow signal is given by $B = B_0 \cos \theta$, where B_0 is the stationary magnetic field originally aligned to give a maximum flow signal and θ is the angular deviation of the sleeve from the orientation of maximum flow signal. Thus, a misalignment of the sleeve over a range of 30° (± 15°) produces an error of only about 4 percent.

It may not always be possible to orient the animal with respect to the magnetic field so as to obtain a maximum flow signal from a given sleeve implant. Calibration is then necessary, to ascertain the magnitude of the magnetic field component effective in inducing the flow signal. This can be accomplished by means of a "calibrating coil" KC (*4*), which is shown in Fig. 7 (bottom) and which is disposed so that its area is perpendicular to the magnetic field when the sleeve is in the orientation yielding a maximum flow signal. The terminals of this coil form the twisted lead L_1L_2. The electromotive force induced in this coil is determined once and for all for optimum orientation in a given external magnetic field. When, in a practical situation, we obtain a signal from the coil KC from a given site of implantation which is a fraction of this maximum signal, we know that the flow signal observed represents the same fraction of the maximum signal observable at optimum orientation. It is more practical to follow the practice of adjusting the sensitivity of the amplifier so as to obtain a standard reading for the signal derived from the coil KC. This will automatically maintain the sensitivity of the flow meter at a constant standard value. Figure 5c shows a record taken of the blood flow in the ascending aorta of a conscious dog with an external attached pair of coils [see Fig. 8 (right)] developing a field of 10 gauss at its center. This record was taken under the most unfavorable conditions—namely, in a moving artery without the use of a compensating coil, at a low magnetic field intensity.

The signal derived from a flow-meter sleeve depends not only on its diameter but also on its length. This is due to the fact that the immobile conductive medium at the two ends of the sleeve represents a load to which the moving blood in the sleeve, acting as a generator, supplies electric power. The current thus engendered gives rise to a drop in the voltage recorded between the electrodes, which becomes more pronounced as the sleeve is shortened. This is illustrated in Fig. 10. The graph at the left was obtained by measuring the flow signal for constant flow with a long flow-meter pipe placed into the magnetic field of a Helmholtz coil. One end of the pipe was connected to a source of saline. The entire pipe was submerged in saline, and its free end was cut shorter periodically until it came to lie next to the electrodes. We see that there is a progressive reduction in sensitivity. The lower curve has been drawn by inference for a sleeve shortened at both ends by doubling the drop in sensitivity below the optimal value observed in the upper curve.

This effect must be taken into account in calibrating a sleeve. If the calibration is accomplished by inserting a pipe into one end of the sleeve, a second calibration should be performed by putting a long pipe (about 15 diameters in length) into the sleeve exit end. The discrepancy between the two readings is to be doubled and subtracted from the reading obtained with the exit pipe in use. This will give a reading corresponding to a sleeve without pipe

Fig. 12. View of a dog's neck, showing four plugs connected to implanted flow meters.

inserts at either end. It is a more reliable procedure, however, to calibrate the sleeve by perfusing with blood an excised artery placed into the sleeve and submerged under blood.

Connections to the Amplifier and Oscillator

The electrodes and the magnet coils are connected to instruments which are described elsewhere (*6*, *7*). The connections are established by suitable plugs. The lead wires are guided from the site of implantation under the animal's skin and are permitted to issue from a small opening in the skin at the nape of the neck. It is very convenient to be able to attach the plugs to the animal's skin at the back of the neck. For this purpose, the outside of the plug is equipped with a thread (cast from TDM), and nylon nuts are used which can be screwed onto this thread. The polyvinyl tubing is bonded well to the Lucite body of the plug to make prolonged submersion in a conductive liquid possible. The entire flow meter, including leads and plugs, is sterilized by submersion in a solution of Zephiran.

Figure 11 shows the manner in which this plug is applied to an animal's skin. A round hole is cut into the skin with a sterile cork borer, and the plug and washers are applied as shown. Figure 12 shows outlets in the neck of a dog, associated with two flow-meter implants. The animals show no discomfort with this method of fixation of outlets. A 10-foot cord connected to the instruments gives the animal ample freedom of motion.

Although the work has been limited so far almost exclusively to animal experimentation, the methods described in this article are suitable for application to human subjects (*17*).

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15. I was greatly assisted in perfecting this type of flow meter by Harry S. Tillson of the Medical School Research and Development Shop. Many important improvements in the manufacturing procedure and design, including the method of molding these units, were suggested and worked out by him. In the latter process the advice and cooperation of Chester Chalberg were very helpful.
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17. I wish to express my gratitude for the generous support of this work by the Office of Naval Research. The coreless flow meters were tested in the course of cooperative research involving chest surgery with different groups. In this connection, I gratefully acknowledge my indebtedness to Drs. Paul H. Crandall, Peter Gall, James V. Maloney, and Lawrence W. Roth. Thanks are also due to Dr. Bennett J. Cohen for his helpful advice. The aid of the Research and Development Shop of the Medical School was of decisive importance, and I wish to thank Chester Chalberg for his never-failing cooperation and Harry Tillson for his valuable contributions. Last but not least, the tireless assistance of Clarence W. Barnes and Raymond T. Kado in the performance of the experiments and in the preparation of the illustrations is gratefully acknowledged.

Science in the News

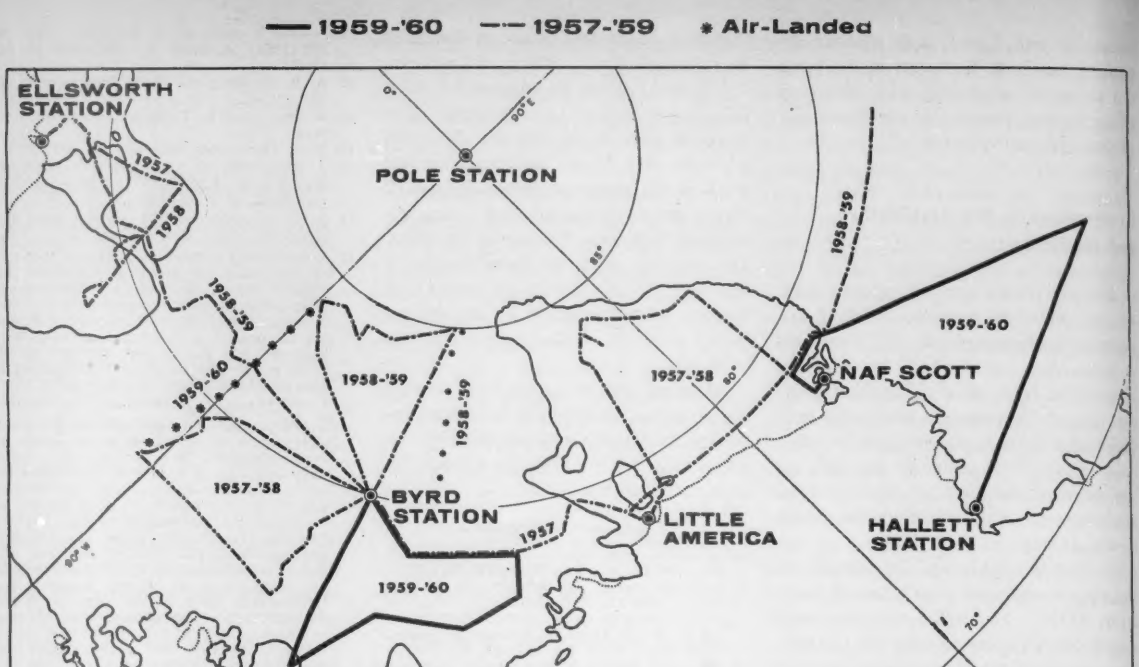
Diplomats Ponder Antarctica's Future as Scientific Studies Are Resumed

Representatives of the 12 countries that participated in the antarctic program of the IGY are now in conference in Washington to negotiate a treaty to assure the continued peaceful use of the continent. The call for the conference was made in May 1958 by President Eisenhower when, citing the "splendid example of international cooperation" afforded by the IGY, he sent invitations to the foreign ministers of the 11 nations that had a role in the IGY antarctic program. Among the delegates attending the meeting, which opened 15 October, are First Deputy Minister Vasily Kuznetsov of the Soviet Union and Prime Minister Walter Nash of New Zealand. At the first meeting of the conference Herman Phleger, head of the U.S. delegation, was elected permanent chairman. The conference may last several weeks.

As the diplomats begin their work, scientists from the United States and other countries, with the onset of the summer season, are resuming the intensive continental studies which began on a large scale with the International Geophysical Year in 1957–58. Approximately 70 scientists are now converging at the half dozen U.S. bases in Antarctica to conduct 29 new projects recently announced by the National Science Foundation and to continue others that were begun under earlier NSF grants. Studies of cosmic rays, geomagnetism, aurora and airglow, and glaciology are among the projects, as well as three mapping programs to be conducted by the American Geographical Society and the U.S. Geological Survey.

Scientific Studies Pushed

In announcing the NSF Antarctic Research Program, which the foundation supports with more than $3 million in grants, Alan T. Waterman, director, said: "Greater emphasis will be placed by the United States on geology, cartography, and biology during the next year." The three cartographic projects call for topographic mapping in the area, revision of maps, and the development of an atlas which will include data on snow accumulation, magnetic variation, and the thickness of the ice sheet. Among the geological studies are projects to determine how long low temperatures have existed on the continent by measurement of the thermolumines-



Completed and projected land traverses of United States scientists in Antarctica.

cence of rock samples, others to devise means of extracting minerals under antarctic conditions, and another, on bedrock geomorphology, to shed light on certain "classic" antarctic problems such as the location of the "Antarctandes" —the extension of Andes Mountains into the continent.

About a dozen biological projects are planned for the current research season. They range from the banding of sea birds to the observation of the men who will take part in one of the land traverses planned for the summer season. This work is part of a continuing collection of data on the performance of participants in the Antarctic program. Past observation has revealed the occurrence of certain behavior patterns among members of traverse teams. For example, prior to crossing a dangerous crevasse area, the traverse party members reveal tendencies toward depression; this is followed by exhilaration when they leave the danger area. During one of the traverses this year, an investigator will try to measure physiological responses to such situations. Other biological projects involve studies of the metabolism of Adelie penguins during the nesting and breeding seasons, studies of airborne organisms, and collection of data on the parasites of antarctic fish.

Logistic support for the scientific programs will be supplied by the U.S. Navy as in past years. The Navy, which identifies its program as Deep Freeze 60, will employ eight ships, 36 aircraft, and about 3000 men in its support activities. Rear Admiral David M. Tyree, who relieved Rear Admiral George Dufek last April, will command the operation. In addition to its support activities the Navy will also conduct a number of hydrographic and meterological surveys and will participate in the mapping programs.

International Control for Antarctica?

At the opening session of the conference in Washington, support was given to a plan for the establishment of an "international regime" to coordinate future activities on the continent. New Zealand, which has vast claims on the 5.5 million square miles of Antarctica, said that it would renounce its claims if such a regime were established.

Territorial claims threaten to be a major stumbling block in the way of a treaty. The delegates from Chile and Argentina objected to internationalization on the grounds of encroachment of sovereignty. Both countries have sizable conflicting claims. The United States and the U.S.S.R. have made no claims to territory and refuse to recognize the claims of others. Britain, Australia, New Zealand, Norway, and France have mutually recognized claims.

In his letter calling for the conference, President Eisenhower stressed the need for an agreement to assure the continuation of "fruitful scientific cooperation" in Antarctica. He suggested that a treaty might be concluded that would have the following purposes: (i) freedom of scientific investigation throughout Antarctica by citizens, organizations, and governments of all countries, and a continuation of the international scientific cooperation which was carried out so successfully during the International Geophysical Year; (ii) international agreement to ensure that Antarctica be used only for peaceful purposes; (iii) any other peaceful purposes not inconsistent with the Charter of the United Nations.

The United States' view is that such a treaty can be concluded without requiring any participating nation to re-

nounce any basic historic rights or claims to sovereignty. The treaty would provide that such rights and claims would remain unaffected while the treaty was in force, and that no new claims would be made. "In other words," the President's letter stated, "the legal *status quo* in Antarctica would be frozen for the duration of the treaty, permitting cooperation in scientific and administrative matters to be carried out in a constructive manner without being hampered or affected in any way by political considerations."

Whether the President's plan or the internationalization proposal will be followed is impossible to say at this juncture. Early indications are, however, that Chile and Argentina, for whom the issue is a major one, will insist that suggestions in the President's letter set the framework for the talks. At the opening session, Adolfo Scilingo, head of the Argentine delegation, stressed the point that the conference was not called "to institute regimes or to create structures. It is not its mission to change or alter anything."

Whatever the decision that may result from the conference, there seems little question that all participants are party to the general agreement that scientific work in Antarctica, such as that which is now being resumed, should be continued and expanded.

British Science Attains Cabinet Status

In accordance with his campaign promise, Prime Minister Harold Macmillan has appointed a science minister, Viscount Hailsham, who will serve under the title of Lord Privy Seal. Hailsham leaves the posts of party chairman and Lord President of the Council. Titles such as Lord Privy Seal and Lord President of the Council originated centuries ago. These posts do not carry departmental responsibilities, the titles being retained to allow for appointments of ministers to oversee specific sectors of the national effort. Hailsham will assume responsibility for the Atomic Energy Authority, the Department of Scientific and Industrial Research, and research in medicine, agriculture, and outer space.

Actually, the appointment does not substantially alter Hailsham's previous responsibility, but only extends it. As Lord President, he devoted part of his time to all of the areas listed except atomic energy, which has been under the direction of the Prime Minister. Now Hailsham will give his full attention to scientific matters. He has already indicated that he intends to concentrate especially on the production of more scientists and on getting the results of research into practical use.

A related appointment is that of Duncan Sandys, former Minister of Defense, as head of a new Ministry of Aviation. He will have charge of the development of guided missiles, radar, and electronics, as well as of the aircraft industry and commercial aviation. Sandys will take over responsibilities borne in the past by the Minister of Transport for Civil Aviation and by the Minister of Supply for research, development, and production of civil and military aircraft, guided and atomic weapons, and radar and electronics.

Press Reaction

The press in this country has paid particular attention to the new emphasis on science in Britain's ruling body, using such terms as "space-age cabinet." However, the British *Economist*, for example, does not give much weight to the trend, saying of Lord Hailsham:

"He now departs bell, book and candle into space: to take ministerial charge of science, a job which was puffed up during the election campaign but which nobody is quite sure really exists." The *Economist* then observes that it would be a great pity if the appointment were the "first step into oblivion" for one of the ablest Conservative ministers, and adds that if Lord Hailsham had been in the Commons he would have been given far greater departmental responsibilities.

The *Economist* article also comments that Sandys has "stepped down" to the new Ministry of Aviation and suggests that the latter is another office which probably should not exist. The article points out that there is an immediate political decision to be taken—whether to give more scope to the private airlines—but that after that the new ministry could "too easily become a collecting place for the pleas of special interests. . . ."

United States observers will study closely the effectiveness of the new cabinet posts. Special interest in the appointments has been generated by the Department of Science bill that is pending before the Congress. The proposed legislation includes a suggestion that there be a secretary for science in the President's cabinet.

Ochoa and Kornberg Win Nobel Prize

The Nobel Prize in physiology and medicine will be shared this year by Severo Ochoa, chairman of the department of biochemistry at New York University, and Arthur Kornberg, executive head of the department of biochemistry at Stanford University. The two men are being honored with the $42,409 award for discoveries related to the synthesis of ribonucleic acid (RNA) and deoxyribonucleic acid (DNA).

These two complex organic chemicals have been under study for years. DNA is the chemical that functions in most living things as the carrier of hereditary qualities. It has been described as providing the master pattern in each cell, allowing that cell to reproduce itself in its own image. It is thought that it plays some role in the production of RNA, which is believed to be essential in the production of protein, the basic material for all living tissue. Further, it is thought that in some viruses, such as the poliomyelitis virus and the tobacco mosaic virus, RNA also passes on hereditary "instructions." Because of the complexity of living cells, it has been difficult to find ways of studying the two chemicals in isolation.

Kornberg's contribution was the discovery of an enzyme that promotes production of DNA from much smaller organic molecules, which are available commercially. Ochoa found an enzyme that fulfills a like function for RNA. Beginning in 1955, Ochoa obtained his enzyme from *Acetobacter vinelandii*, the bacteria that turn alcohol into acetic acid. In 1956 Kornberg found his enzyme in the common intestinal variety of the bacterium *Escherichia coli*. He put this to work to produce DNA but found that magnesium salts must be present with the primer to start the reaction.

The research, which was conducted independently by Kornberg and Ochoa, has made it possible to use these enzymes for synthesis of compounds that appear to be virtually identical with DNA and RNA physically and chemically, although they have not yet been shown to be biologically active. The work has clarified many of the questions about cellular reproduction and protein formation.

The Two Careers

Ochoa, who is 54 years old, was born in Spain, where he received his medical degree with honors from the University

Two American biochemists will share the 1959 Nobel Prize in physiology and medicine for their separate investigations of nucleic acids: (left) Severo Ochoa, chairman of the department of biochemistry at New York University, and (right) Arthur Kornberg, head of the department of biochemistry at Stanford University.

of Madrid in 1929. He did graduate work in Glasgow, Berlin, Heidelberg, and London. He began his career as an educator at the University of Madrid in 1931. Later he moved to Heidelberg, Plymouth, and Oxford, obtaining his first appointment in the United States in 1941, when he became an instructor and research associate in pharmacology at Washington University, St. Louis. In 1942 he accepted a post as research associate in medicine at New York University, where he has remained ever since. He was named chairman of the department of biochemistry in 1954.

Kornberg was born in Brooklyn in 1918. He received a B.S. degree from the College of the City of New York in 1937 and an M.D. degree from the University of Rochester in 1941. For approximately 10 years he was with the U.S. Public Health Service, where he advanced through grades to become a medical director. During this period he served on the staff of the National Institutes of Health in Bethesda, Md. There he spent 3 years in the nutrition section, then became chief of the section on enzymes and metabolism. In 1952 he was named professor and head of the department of microbiology at Washington University, where he remained until last July, when he accepted his present post at Stanford as professor and executive head of the department of biochemistry.

The Karolinska Institutet in Stockholm makes the annual selection for the Nobel awards in physiology and medicine. The physics and chemistry prizes will be announced by the Swedish Royal Academy of Science about 26 October. The three scientific awards will be presented in Stockholm on 10 December, Alfred Nobel's birthday.

U.S., Soviet Student Exchange Program Up for Study

The future of the student exchange program between the United States and the Soviet Union, now beginning its second year, will probably be determined during talks in November between U.S. and Soviet officials. The program is conducted under the Lacy-Zaroubin pact, signed last year, which was also the basis for the recently announced exchange of scientists between the two countries' academies of science.

Experience last year, when 21 American graduate students studied in the U.S.S.R. and 17 Russians studied here, indicates that several problems must be overcome before the future of the program, which is now regarded as experimental, is assured.

The major problem, from the American point of view, is the limited access that U.S. scholars are given to laboratories, archives, and other facilities in the Soviet Union. This handicap, which many students reported after last year's experiment, caused such difficulties that the Inter-University Committee on Travel Grants, the coordinating body for students from American Universities, remonstrated with the Soviet Deputy Minister of Higher Education in a letter sent last month. The letter, sent by David C. Munford, head of the committee, implied that the exchange experiment might be terminated if major improvements were not forthcoming during the current academic year. Although no reply has yet been received from the Soviet minister, M. A. Prokoviev, the American officials are confident that full consideration will be given to problems arising from the exchange. There is often a reluctance on the part of Soviet officials to deal with such problems in correspondence. The approach which has proved most valuable is informal discussions between principals. Such discussions are planned for November. It is expected that either Munford will travel to the Soviet Union, or that a small Soviet delegation will visit the committee's headquarters at Columbia University.

Free Access Given Here

In his letter, Munford stressed the fact that Russian students visiting this country under the plan are given the most free access possible. In addition, American universities go to great lengths to assure the best conditions for the foreign students, including the opening of areas closed to most Russian visitors. On the other hand, according to the reports of American students, the conditions in the U.S.S.R. are quite restrictive. Limited or de-

layed access to archives and libraries hampered work. Travel restrictions were maintained, and difficulties were encountered in establishing free and open social relations with Russian students.

The second year of the program, which is now beginning, calls for the exchange of 32 Soviet graduate students for 27 Americans. The Americans represent 14 universities around the country. Many of the Russian students, following the pattern set last year, will work in science and technology. This year, for the first time, some of the American students will also work in these fields.

Argonne International School To Become International Institute

The International School of Nuclear Science and Engineering at the U.S. Atomic Energy Commission's Argonne National Laboratory, Lemont, Ill., will expand its activities and broaden its program to help meet new scientific needs of nations throughout the world. The change will become effective in February 1960, after completion of the school's ninth session in December. The school will then be known as the International Institute of Nuclear Science and Engineering.

The institute will give greater emphasis to advanced training and will offer less background instruction, inasmuch as this type of training now is becoming available in colleges and universities. Personnel enrolled in the institute will represent the United States and many foreign countries. Instruction in the institute, like that of the school, will be on an unclassified basis.

Appointment to the Institute

Rollin G. Taecker, director of the international school, who will be director of the institute, emphasized that the new curriculum will be entirely on a postgraduate level, requiring for entry the equivalent of a master's degree from a United States university. As is the case with the present international school, all those taking part in the new program must be sponsored by industry, government, or the atomic energy agency in their home country. Scientists and engineers appointed to the institute will follow two types of program objectives. The first, the "participant" appointment, will require the equivalent of a United States university's master's degree and a background in fundamental nuclear studies. Participants may be selected for one or two 16-week terms. Instruction will emphasize the applied aspects of nuclear science. Tuition for participant appointees will be $1000 per term.

The second, or "affiliate," appointment level will require the equivalent of a United States institution's doctor of philosophy degree. Affiliates will be accepted for no less than two terms. Preferably, their stay at Argonne will be a full calendar year. Their abilities must be such as to enable them to contribute significantly to the over-all Argonne scientific research program.

At the beginning, appointments to the institute will be made in five program areas. These are: reactor science and technology, engineering research and development, physical science research, life science research, and the engineering, administration, and operation of nuclear facilities. When the new International Institute first opens in February, programs in all but the fifth area of instruction will be offered. The engineering, administration, and operation course sequence will start with the institute's second term, which begins in June.

During the last seven of the nine sessions of the school at Argonne, the U.S. Atomic Energy Commission has drawn on the facilities of North Carolina State College and Pennsylvania State University to provide initial training for students enrolled in its international program. Since several other universities throughout the world now have comparable nuclear training courses and equipment, this phase will cease with the beginning of the institute.

Through its first eight sessions, the International School of Nuclear Science and Engineering at Argonne has trained 478 scientists and engineers, 102 from the United States and 376 from 43 foreign countries. Forty-four scientists and engineers are attending the current session of the school.

Conquest Programs Resumed

Conquest, a CBS television series that is prepared in cooperation with the AAAS, will resume broadcasting of weekly half-hour Sunday programs, 5 to 5:30 P.M. EST, beginning 1 November. News correspondent Charles Collingwood is host-narrator of the telecasts, which will explore new developments in various fields of science. The subjects to be covered in the 20 shows scheduled include tuberculosis, embryology, oceanography, fallout, streptococcus, evolution, and solar research.

The opening program deals with the nature of mother love as determined by experiments on baby rhesus monkeys. The work will be demonstrated by Harry Harlow, University of Wisconsin psychologist, who is conducting the research. *Conquest* is sponsored by the Monsanto Chemical Company.

International Committee To Study Technical Literature Problems

A committee representing 10 countries was named at the closing session of the International Conference for Standards on a Common Language for Machine Searching and Translation to continue the work of the conference. Co-sponsors of the meeting, which met in Cleveland, Ohio, 6-12 September, were Western Reserve University and the Rand Development Corporation. The new group will conduct studies under the four main headings of research, nomenclature, exchange of materials, and information and exchange of personnel.

Brian Vickery of Imperial Chemical Industries of Great Britain was elected president of the committee. Allen Kent, associate director of Western Reserve's Center for Documentation and Communication Research, was elected general secretary. Vice-Presidents are J. Dekker of the Netherlands, S. R. Ranganathan of India, Rudolph Bolting of Brazil, and a representative, yet to be named, of the U.S.S.R. Sponsorship will be sought by the committee from existing agencies, such as the International Standards Organization and the United Nations.

The conference in Cleveland was an experimental effort to combat the problems associated with the growing mass of technical literature. More than 200 persons from 10 countries—Brazil, France, India, Italy, Japan, the Netherlands, the United Kingdom, the United States, the U.S.S.R., and West Germany—heard 55 formal papers reviewing work in progress in machine literature searching, machine translation, and language studies for machine searching, correlation, and translation.

The featured speaker of the week was Senator Hubert H. Humphrey (D-Minn.) who, in discussing "Knowledge

is Power," stressed the need for improved mechanical information services on a coordinated basis and for more cooperation within the United States as well as among the various nations of the world. The Senator deplored the slow start made by U.S. government agencies in recognizing the problem of the burgeoning technical literature and in taking effective steps to support new ideas for controlling it.

The proceedings of the conference are to be published in March 1960 by Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N.Y.

Pharmacologists Form International Body

At the 21st International Union of Physiological Sciences held in Buenos Aires in August 1959, a Section on Pharmacology of the IUPS was created and empowered to arrange for symposia, conferences, and congresses and to carry out fellowship programs as well as other activities that will contribute to the advancement of pharmacology. An organizing meeting of the new section was held on 11 August. It was decided to build the new section around the already existing International Council of Pharmacologists, which contains one representative of each nation or region that adheres to the IUPS. The following executive committee was elected: president, Carl F. Schmidt (U.S.A.); vice president, S. Anitchkov (U.S.S.R.); secretary, D. Bovet (Italy); and treasurer, D. M. Aviado (U.S.A.).

Grants, Fellowships and Awards

Radiology. On behalf of the James Picker Foundation, the National Academy of Sciences–National Research Council has announced a new fellowship program, the James Picker Foundation Advanced Fellowships in Academic Radiology. These awards are offered in addition to the previously established research fellowships and scholar and research grants, which will be continued during 1960–61.

The new program is designed to prepare a candidate to meet in full the demands of an academic position in radiology. In general, it is expected that a candidate will be not more than 33 years of age and will have completed his clinical training. He should be prepared to devote a minimum of 2 years to course work in the basic sciences, to the application of the techniques and methods of these basic disciplines to radiological research, and to other activities designed to enhance his preparation for an academic career. Applications will be accepted on nomination by a candidate's clinical adviser, who should be a member of the staff of a department of radiology in a medical school.

The previously established program of the Picker Foundation, for which applications again are being invited, comprises three types of awards: postdoctoral fellowships in radiological research; grants for scholars, a transitional form of support to bridge the gap between the completion of research fellowship training and the period when the young scientist has thoroughly demonstrated his competence as an independent investigator; and grants-in-aid of research, designed to encourage investigations offering promise of improvement in radiological methods of diagnosis or treatment of disease.

Applications in all four categories will be reviewed by the Committee on Radiology of the Academy–Research Council's Division of Medical Sciences. Final determination of awards is made by the foundation upon recommendation of the division. Support is not restricted to citizens of the United States or to laboratories within this country.

Applications for 1960–61 should be submitted by *15 December*. Further details and application blanks may be obtained from the Division of Medical Sciences, Room 411, National Academy of Sciences–National Research Council, 2101 Constitution Avenue, NW, Washington 25, D.C.

The National Research Council of Canada serves as scientific adviser to the James Picker Foundation with respect to its Canadian program. Accordingly, if the proposed studies are to be carried out in Canada, requests for information and application forms should be directed to the Awards Office, National Research Council of Canada, Ottawa 2, Canada.

Summer conferences. The National Science Foundation has announced that it will continue to support in 1960 an experimental program of some 20 Summer Conferences designed primarily for college teachers of engineering, science, and mathematics. The Summer Conferences are of shorter duration than, but generally similar to, the Summer Institutes that the foundation has supported in recent years.

Colleges and universities interested in sponsoring such conferences are invited to request further information from the Program Director for Summer Institutes, National Science Foundation, Washington 25, D.C. The deadline for submitting proposals is *15 December*.

Teacher training. The National Science Foundation has announced that approximately 550 summer fellowships for graduate teaching assistants will be offered for the summer of 1960. Designed to enable graduate teaching assistants to devote their full summer to study and research, the fellowships will be offered in the sciences, mathematics, and engineering.

In this, the second year of operation of the program, teaching assistants at 150 institutions that are authorized to confer the doctoral degree in at least one of the sciences will be eligible to apply for summer fellowships. First-year participation in the program had been limited to 115 institutions which had awarded a specified minimum number of science doctorates.

Teaching assistants at the participating institutions should apply through their own institutions and will be screened and evaluated initially by their faculties. Summer tenures from 8 to 12 weeks may be selected by the fellow. The stipend will range from a minimum $50 per week up to a maximum of $75 per week.

Awards will be provided for study in the mathematical, physical, medical, biological, and engineering sciences, as well as in anthropology, psychology (excluding clinical areas), and certain selected social sciences. The social sciences included are geography, mathematical economics, econometrics, demography, information and communication theory, experimental and quantitative sociology, and the history and philisophy of science, where they conform to accepted standards of scientific inquiry by fulfilling the requirements of the basic scientific method as to objectivity, verifiability, and generality.

Application materials may be obtained from the graduate dean of a participating institution, or from the Fellowships Section, Division of Scientific Personnel and Education, National Science Foundation, Washington 25, D.C. Applications must be submitted to the graduate deans by *11 December*.

Scientists in the News

The University of Paris has conferred the title of *docteur honoris causa* on **Soloman Lefschetz**, honorary professor and former chairman of the mathematics department at Princeton University.

Rollo Clyde Baker, emeritus professor of anatomy and former assistant dean and secretary of the Ohio State University College of Medicine, has received the university's Distinguished Service Award.

Louis I. Dublin, consultant to the Institute of Life Insurance on community health and welfare activities, has received the Sedgwick Memorial Medal "for distinguished service in public health" at the 87th annual meeting of the American Public Health Association.

Alvin Nason, professor of biology at the Johns Hopkins University, has been appointed associate director of the university's McCollum–Pratt Institute.

New appointments at Case Institute of Technology include the following:

Gordon Barrow, associate professor at Northwestern University, has become professor and head of the chemistry department.

Frederick Reines, group leader at the Los Alamos Scientific Laboratory, has become professor and head of the physics department.

James Reswick, associate professor of mechanical engineering at Massachusetts Institute of Technology, has become professor of mechanical engineering.

Edwin Abrahamson, assistant professor of chemistry at the College of Forestry, Syracuse University, has become associate professor of chemistry.

C. M. Yonge, Regius professor of zoology at the University of Glasgow, Glasgow, Scotland, has been appointed visiting professor of zoology at the University of Washington, for the fall quarter of 1959.

Clifford W. Seibel, former assistant director of the U.S. Bureau of Mines in charge of helium activities, has been appointed consultant in cryogenic engineering and design and construction of helium recovery facilities at Stearns-Roger Manufacturing Co., Denver, Colo.

Herbert Jehle, professor of physics at the University of Nebraska, has been appointed professor of physics at George Washington University.

Herbert B. Brooks, retired chief of the electrical section of the National Bureau of Standards, has been named the first recipient of the Morris E. Leeds Award of the American Institute of Electrical Engineers. The $500 award was established in 1958 by the Leeds and Northrup Foundation to honor an individual or a group for outstanding contributions to the field of electrical measurement.

William A. Del Mar, consulting engineer for the Phelps Dodge Product Corp., Yonkers, N.Y., has been named the first recipient of the AIEE's $500 William M. Habirshaw Award. The award was established in 1958 by the Phelps Dodge Foundation to honor individuals or groups for outstanding contributions in transmission and distribution of electricity.

The AIEE Medal in Electrical Engineering Education was presented to **Gordon S. Brown**, dean of engineering at Massachusetts Institute of Technology.

Howard E. Page, scientific director, Office of Naval Research Branch Office, London, England, has been appointed special assistant to the head, Office of Special International Programs, National Science Foundation.

B. F. Skinner, professor of psychology at Harvard University, will deliver a series of four Mead Swing Lectures at Oberlin College on 27, 28, and 29 October. His subject will be *The Design of a Culture.*

William G. Dauben, professor of chemistry at the University of California, Berkeley, has received the ninth annual award of the California section of the American Chemical Society, for his achievements in organic chemistry.

R. Chester Roberts has retired after 31 years as chairman of the department of chemistry at Colgate University. He is serving as visiting professor of chemistry at Oberlin College for the fall term.

Lester C. Shell, premedical adviser at Central College, Fayette, Mo., has been appointed head of the department of biology at the University of Dubuque.

George Y. Shinowara, professor of pathology at Ohio State University, has been appointed professor of pathology at the New York University College of Medicine. He will be director of a new laboratory which has been established in the NYU-Bellevue Medical Center to carry on research in the study of blood, tissue proteins, and coagulation components. He will also be director of biochemistry for Bellevue Hospital and for New York University Hospital.

Stanley I. Auerbach, ecologist at Oak Ridge National Laboratory, has been appointed chief of the newly established ecology section in the Health Physics Division of the laboratory.

Recent Deaths

Calvin D. Albert, Ithaca, N.Y.; 82; professor emeritus of machine design at Cornell University; author of *Machine Design Drawing Room Problems*; 23 Sept.

Walter H. Eddy, Lake Worth, Fla.; 82; professor emeritus of physiological chemistry at Teachers College, Columbia University, and a pioneer in vitamin research; 28 Sept.

Ross G. Harrison, New Haven, Conn.; 89; retired director of the Osborn Zoological Laboratory of Yale University and Sterling professor of biology emeritus at Yale; former chairman of the National Research Council; pioneer in the embryonic transplantation and culture of animal tissue outside the organism; 30 Sept.

Robert Livermore, Sr., Boston, Mass.; 83; mining engineer and founder and former vice president of North American Mines, Inc.; 26 Sept.

Harold Pender, Kennebunkport, Me.; 80; co-founder, director, and consultant of the International Resistance Co.; former dean of the Moore School of Electrical Engineering at the University of Pennsylvania; 5 Sept.

Sir Henry Thomas Tizard, London, England; 74; scientist who was largely responsible for the development of radar and contributed to the development of the atomic bomb and the jet engine; former president of Magdalen College, Oxford University; 9 Oct.

Milton C. Winternitz, Hanover, N.H.; 74; pathologist; dean emeritus and retired head of the pathology section of Yale University School of Medicine; Anthony N. Brady professor of pathology; 3 Oct.

Book Reviews

Village Japan. Richard K. Beardsley, John W. Hall, and Robert E. Ward. University of Chicago Press, Chicago, Ill., 1959. 498 pp. Illus. $8.75.

Village Japan is the principal report of an extraordinary research project carried out by the University of Michigan's Center for Japanese Studies. A rural settlement of only 24 households was observed over a span of 7 years by members of an interdisciplinary research team composed of both Americans and Japanese representing anthropology, history, economics, political science, and geography, to name only the major fields. In studies basically concerned with cultural anthropology, seldom has so much been devoted for so long to so few.

This is not the place for the query "Is the return worth the investment?" In any event, the book is without question the best report on a Japanese village in English or, in my opinion, any other language. It combines great richness of detail with mature reflection and excellent organization. It excels other Western attempts most notably, perhaps, in the sense of history (both recent and traditional) it gives, in its comprehensive treatment of Japan's major rural economy, and in its admirable description and analysis of local government and politics. These merits undoubtedly derive from the fact that interdisciplinary members enlarged the anthropological team. Though the total of rural studies in Japanese, of course, furnishes better documentation, I know of no single, native study that covers as much of the classic, ethnographic catalog in a manner nearly as comprehensive; in addition *Village Japan* lacks the *parti pris*—ideological, disciplinary, or cultural—that so often makes a Japanese work suitable for special, rather than general, use.

One of the study's most welcome contributions is its careful and convincing treatment of recent cultural change. We might assume that the postwar period would have seen a more positive flowering of numerous hitherto only tentative trends born of modernization. Research for this study began late enough (1950) to escape the confusing cross-currents and massive novelties of the immediate postsurrender years, and it lasted late enough (into 1957) to capture whatever set occurred during this era. Here, as in other studies where time and reflection have been given to the viewing, one is impressed by the almost organic continuity of the culture. Erosion, replacement, and addition have come, but they do not appear to have compromised greatly the character of the entity they modify. As the authors put it, the villages "maintain equilibrium, while absorbing fundamental change."

The mechanization of agriculture has increased considerably, but on the whole as a clever, economical complement to traditional tools and techniques. Commercialization has proceeded in depth, but only in a way that proportionately diminishes, but does not undermine, the old base of subsistence. Specialization of occupations, especially in nonrural jobs, has developed to a remarkable degree, but without abruptly divorcing the new workers from their farm families, and only concurrent with a general "rurbanization" that gives the farmer a not unequal role in a developing national, occupational, and cultural system. Communal sharing of labor has virtually disappeared as cash, new tools, and job specialization have provided viable alternatives, but *de facto* primogeniture in inheritance continues as a practical way to handle tiny land holdings. A mass of new administrative and communal organs and procedures, from a parent-teachers association to universal adult suffrage, have come in on the wings of modernity, the Occupation, and government centralization, but they have been incorporated into the traditional system of communalistic decision. The lyric of individualism fills these literate people's ears, but individualism continues to be judged for reality with a traditional, wary consciousness of its implications for cherished collectivistic norms. By contrast, in a matter like that of food habits, only very limited modifications have, in fact, been made. If one has to label this process of change, perhaps its salient characteristics are experimentalism, guided by some form or analogue of rational calculation, with a tenacious aim of fortifying a continuing cultural entity. It is difficult to discover in other sources comparable and systematic data on change in the city, and city change is certainly far more chaotic, in part because invention begins there. One inclines, however, to accept the hypothesis that the basic features which the process of change exhibits in the village are likewise characteristic nationally, and even historically, in modern Japan. The book makes a real contribution toward the solution of this problem.

The authors' treatment of ethnographic areas is almost consistently of high competence. Nonetheless, their treatment of local government and politics is, perhaps, of particular value. Too much opinion about Japan, and unfortunately too many studies both Japanese and Western, have assumed the maximization of personal and class interest in government and for this reason have interpreted even local manifestations as autocratic to an exceptional degree. It is refreshing that the authors feel that to assume the maximization of group interest as a norm and motive allows them to explain, perhaps, more of the relevant Japanese behavior. On this interpretation, one perceives the limitations and responsibilities of leaders, as well as followers, and the dominance of discussion, compromise, and consensus as modes of political operation.

If, to balance the pleasure and profit given by this book, one wants to discover its shortcomings, two points may deserve mention. For one, the title, as well as recurring comments on variation elsewhere in Japan, give the impression that the authors are to a degree generalizing for the rural culture as a whole. Specifically, they both claim and disclaim this intent, and indeed on this point the book deserves their ambivalence. Intuitively, I feel there is enough homogenity to the rural culture to make this a reliable source on most of it. The data reported, however, are almost entirely tied to observation of one settlement, and the comparative remarks tend to be haphazard and, so far as is demonstrated by their specificity and documentation, impressionistic. This seems inappropriate, since there is enough material on rural Japan today to allow empirical generalization for

the country as a whole with respect to a wide range of cultural traits, and some work directed to this end has been and is being done elsewhere. One does not, of course, imply censure of the authors for not adding another prodigious feat to their present one. It is worth emphasizing, however, that this book is not a study of rural Japan as a whole which, to some mild degree, it appears to be; such a study could have been, and still must be, written to complement *Village Japan*.

The final comment is even more simply a lament for what the authors, with their great resources, might have done. The book is fundamentally a thoroughly conventional ethnography, raised to an undoubtedly high level, but still conventional. The consequence that most grieves me is that it leaves one with the curious sense that there were no human individuals in the village. There is excellent generalization of behavior and institutions, but biographies, the delineation of individual motivational situations, or those other vehicles that might have carried to us the sight and sound of the villagers themselves are virtually excluded. A sheaf of good pictures showing normally lively-looking Japanese going about their lives merely compounds the sense of deprivation. More seriously, one gathers that the authors object to culture and personality or national character approaches. It is certainly true, as they assert, that rural social norms severely limit individualism. It may also be true that the villagers in question exhibit, even for rural Japan, a peculiar sense of propriety toward these norms. It may even be true, as is stated in the foreword, that foreigners never become "members of the (small rural) community" in Japan, with the implication that the observers were thus excluded from many intimacies. Nevertheless, unlike many other students of Japan, the authors did not live in the community (a technically debatable procedure), and it is patent that elsewhere many Americans and Japanese have taken one another about as far as possible into their individual lives. It is, after all, the individuals of Niiike who would have enriched the work, didactically as well as empathically. It is scarcely inventive to remind ourselves that much of the efficient logic of culture lies in the interaction of standards and the native individual. Moreover, one can argue that a peculiarly central problem in the study of Japanese culture is the dialectic between social

Kumagai Motoichi. Dolls are arrayed on shelves for Girls' Day. [From *Village Japan*]

norms that are among the world's most rigidly collectivistic and human norms that are among the world's more highly expressive. It is this tension that has overwhelmingly animated a great artistic and literary tradition, yesterday as it continues to do now, at the popular and at the sophisticated level. If the villagers of Niiike do not, in fact, engage strenuously in this dialogue, then one wants proof and discussion of their alienation from the great tradition. This is admittedly gratuitous advice. If Hamlet has been left out of the play which we know is so peculiarly appropriate to him, it is because we are here observing a different dramatization. The public interested in Japan, as well as orientalists and a host of other specialists, will be in deep debt to the authors and their sponsoring Center, for years to come.

JOHN C. PELZEL
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From Galaxies to Man. John Pfeiffer. Random House, New York, 1959. 184 pp. $3.95.

Probably no one has tackled a larger subject since Humboldt started to write his *Cosmos*. Pfeiffer's subject is no less than the history of the entire universe from the beginning into the future. The theme runs through the origins of galaxies, of stars, of the elements, of planetary systems, of life and of man, and on into a final chapter titled "Futures in space." The drama has a cast of billions; it is truly supercolossal.

In so great an undertaking, even a modest success would be praiseworthy. Pfeiffer's success may not be complete, but it is better than modest. He has summarized this vast story in words that anyone can understand; he has conveyed a sense, at times almost breathless, of the excitement of it all; and he has fallen into practically no positive errors. That is indeed a remarkable accomplishment, and one that can be highly recommended.

Such a success has its price, or its qualifications that may be discussed more in commiseration with the author than in criticism of him. For one thing, the logical start is with those awesome words "In the beginning"—and we (as scientists) do not know what was in the beginning, or even whether there was a beginning. Each great segment of the history starts with mystery, with ignorance, with (to be frank) wild guessing. Pfeiffer does not evade this issue or mislead the reader. He stresses, even at times overstresses, the provisional character of hypotheses about origins. He exploits the fascination of beginnings and pays the price that much of the book, therefore, admittedly lacks a solid foundation.

The style of writing also contributes to the success of the book, and also at a certain cost. It is rhetorical (in a good sense), often poetic, sometimes deeply moving. Few books on science are written so well or are more likely to convey humanistic values. The balance and the price may be indicated by two random quotations.

"Particles dart and swerve and bounce off one another, and sometimes stick together. They form shapes and fragments of shapes, Tinker Toy lattices and crosses and branching structures and unclassified patterns resembling the forms in some modern paintings." Something exciting is going on here, but what? In this and many other passages there seems to be more action than information.

"The earliest naked genes may not have been particularly good at making images of themselves. They must have erred frequently. After all, they were new hands at a difficult job. . . ." That is a vivid introduction to what could be a dull topic. Is it, perhaps, just a bit *too* vivid? The stylistic trick of personalization, if overworked, comes close to animism.

Those remarks add up to no more than saying that this is one kind of

popularization of science and not another kind. It is a good kind: nondidactic, indulgent of admitted flights of fancy, highly eloquent, and at the same time, conscientiously based on current professional consensuses. Scientists are fortunate to have such an interpreter, and the book deserves wide lay notice.

G. G. SIMPSON
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Medical Biology and Etruscan Origins. Ciba Foundation symposium. G. E. W. Wolstenholme and Cecila M. O'Connor. Little, Brown, Boston, Mass., 1959. xii + 255 pp. Illus. $9.50.

This volume is one of a series published by the Ciba Foundation to promote international cooperation in medical and chemical research. The 50th Ciba symposium departed from the narrower range of previous conferences and chose as its subject "The recent contributions of medical biology to ethnology; with special reference to the origin of the Etruscans." This book contains the papers read as well as the discussions which followed and spans the gap between science and the humanities, a bridge that archeology bitterly needs.

The choice of title was not very felicitous since it seems to promise more results achieved by medical science in the study of Etruscan origins than the book provides. Half the book deals with special phases of Etruscan archeology—for example, cities, origin of the culture, oriental characteristics of the religion, relationship of Etruscans to Villanovans and Umbrians—by outstanding scholars from Europe and America. The second half, however, is largely devoted to medical and anthropological investigations in ancient fields, written from a general point of view—for example, "The evaluation of metrical data in the comparison of ancient and modern bones" (N. A. Barnicot and D. R. Brothwell), "The use of genetical characters as indices of population distribution" (A. E. Mourant), "Blood groups and haematological data as a source of ethnic information" (R. Ceppellini)—with a minimum of data on the ancient Etruscans. The papers on the various topics are most illuminating and the discussions most interesting, but the results in terms of Etruscology are disappointing.

The difficulty of recognizing the ancient Etruscans in Italy, a difficulty enhanced by the lack of scientific digging in the early excavations, is clearly expressed. The further difficulty of identifying Etruscans in the mixed populations of ancient Cyprus, Syria, and Anatolia is scarcely touched upon. The development of the Etruscan culture in Italy and its relation to that of Central Europe is emphasized; the origins of the culture (art, techniques, language, and so forth) in the orient, except for the religion, is neglected. There emerges, however, the strong hope that great progress in the solution of the Etruscan problem may be attained if careful digging is combined with medical research and physical anthropology.

The papers are ably written, the archeology is admirably illustrated, and the book is excellently published. The price for the scholar, however, is high. The Ciba Foundation may be congratulated on taking a bold, forward step and in pointing the way to new fields of investigation.

CLARK HOPKINS
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Group Theory. And its application to the quantum mechanics of atomic spectra. Eugene P. Wigner. Translated from the German by J. J. Griffin. Academic Press, New York, expanded and improved edition, 1959. xi + 372 pp. $8.80.

This volume is essentially a direct translation into English of the classic 1931 edition that was published in Geman. It includes, in addition to the original content, three new chapters; chapter 24, "Racah coefficients," chapter 26, "Time inversion," and chapter 27, "Physical interpretation and classical limits of representation coefficients, three- and six-*j* symbols." Much that is contained in these new chapters has not previously appeared elsewhere in print.

When the book was first published in 1931, and for a number of years after, many physicists were reluctant to accept group theory as an essential tool of theoretical physics. Just a few physicists, including Wigner, recognized that the theory of representations of symmetry groups provides a systematic method for obtaining those properties of the solutions of the Schrödinger equation which follow from the symmetry of the physical problem. Furthermore, almost every exact statement concerning solutions (exact or approximate) of the Schrödinger equation is a direct consequence of a general symmetry property. The importance of this point of view is now widely recognized among physicists not only in connection with the Schrödinger equation, but also in connection with relativisitic theories. Although group theory is not widely accepted as an essential part of the standard graduate course in quantum mechanics, it should be studied, at least by the prospective theorist, as supplementary material.

Wigner's *Group Theory* provides an excellent introduction to the subject for the physicist. It is very explicit in its handling of the theory of representations, as well as in its physical applications. A number of specific examples are treated in detail. The domain of physics encompassed by the examples is not very great; applications are limited (with one or two exceptions) to problems in atomic structure. The treatment of abstract group theory is purposely minimal. Therefore the book is probably more suitable for use as a supplementary rather than a primary source for study of the purely mathematical aspects of the subject. The basic ideas of quantum mechanics are reviewed, but, again, the book would not serve as a primary text of quantum mechanics. To reap the greatest value from this book, the student should already have a substantial knowledge of this subject. However, the sections devoted to quantum mechanics are well worth reading, for they provide an excellent and concise statement of the physical interpretation, and they give Wigner's perspective, which always has new and enlightening facets.

The rotation-inversion group in three dimensions along with some of its subgroups and the symmetric (permutation) group are treated in detail. The discussion of the representations of the symmetric group is limited to those irreducible representations which are significant in atomic structure; this does not include the complete set. Young's symmetry operators are not mentioned. This is unfortunate since, as Wigner was the first to show in his important 1937 papers on the symmetric Hamiltonian, some of the other representa-

tions are important in the study of nuclear structure. From the point of view of modern usage, it would also be desirable to have some discussion of the generators of infinitesimal rotations, their commutators, and so forth. They were not treated in the original volume, hence not in this version of the book.

The new chapters will be of interest to all theorists. In particular, the discussion of the corepresentations of a group involving antiunitary operators gives a new insight into the mathematical consequences of invariance under the operation of time inversion. This chapter would benefit from an amplification of the physical meaning of time inversion since the symmetry involved does not yield as easily to intuitive reasoning as do symmetries in configuration space.

On the whole, the chapters from the original bear up remarkably well against the passage of time, and the new chapters add further to the value of the book. The translation seems excellent; none of Wigner's personal touch appears to have been lost in translating.

ROBERT G. SACHS
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Target for Tomorrow. Space travel of the future. I. M. Levitt. Fleet Publishing Corporation, New York, 1959. 328 pp. Illus. $4.95.

Since the first artificial earth satellite was successfully launched by the U.S.S.R. nearly 2 years ago, there has been a substantial marshalling of engineering and scientific resources in this country for the exploration of space. Undertakings of this nature are costly, so much so that, to the present, only governments have been able to afford them. The support for such enterprises rests, therefore, on the public. There would be cause for considerable satisfaction if the approval of the measures taken to establish the American space program could be considered indicative of the public's understanding of the subject. Unfortunately, the emotional reactions to the early difficulties deny the possibility of any such comforting conclusion. Moreover, the scientific and engineering aspects of space exploration touch on so many of the branches of pure and applied science that it is, perhaps, unreasonable to expect very many, even among the best informed, to comprehend them all.

There is, consequently, a need for sound information at all levels concerning the aims, prospects, and problems of space exploration. Without a well-informed public, capricious reactions might well jeopardize any hope for a constructive program founded on scientific values rather than exhibitionism.

The present work represents an attempt to inform the "educated layman" about the development of rocket propulsion, the creation of artificial satellites, and some of the possibilities and problems in the future evolution of the exploration of space. The wide range of topics discussed includes the characteristics of the earth and its atmosphere, gravitation, celestial mechanics, satellites and space stations and their uses, hazards in space, the problems of supporting human life in space, interplanetary and interstellar travel, and the effects of motion at relativistic velocities. Two appendixes deal, respectively, with some statistical speculations about the hidden side of the moon and with the author's views on educating and training space engineers. Some 36 black-and-white illustrations are provided; about half of these are photographs of a selection of astronomical objects, and the remainder are artists' conceptions of various aspects of space travel.

It is doubtful whether, in its present form, the book is appropriate for the educated layman, although much of the material has been reprinted from the author's newspaper articles. I believe that most readers possessed of sufficient scientific knowledge for ready comprehension of the subject matter may find the work rather awkward and uninspired, while those not so informed may find it difficult to understand many of the technical explanations because of the lack of sufficient clarity and precision. It is unfortunate that the literary style and exposition do not reach the standards of the best popularizers of scientific subjects.

Perhaps the best feature of this book is found in the considerable amount of elementary information about astronomy, celestial mechanics, and astrophysics which it contains. Although for the most part, these subjects are correctly, though not always clearly, explained, it is surprising to find an erroneous description of the behavior of a satellite of the earth in a polar orbit (page 124).

Although a fair account is given of some of the scientific investigations which have been or will be conducted, I was disappointed to find very little discussion of the results obtained so far from satellites and space probes.

If, as the preceding remarks indicate, the book falls short of the goal set for it, the author is nevertheless to be commended for assembling a great variety of information relating to the subject.

J. P. T. PEARMAN
National Academy of Sciences,
Washington, D.C.

Die pränatalen Infektionen des Menschen unter besonderer Berücksichtigung von Pathogenese und Immunologie. Heinz Flamm. Georg Thieme, Stuttgart, Germany, 1959. xii + 136 pp. $4.70.

The dramatic announcement in 1941 by N. McA. Gregg, an Australian ophthalmologist, that he had examined 78 children with congenital cataract (44 of whom also had heart defects), born to mothers who had contracted rubella during the first three months of pregnancy, and the subsequent confirmation and extension of these findings by a special commission aroused great interest among scientists and laymen in the dangers that result from infection to which the human embryo and fetus may be exposed during pregnancy.

The author of the present book undertook the task of giving an account of the current status of clinical and experimental work in this field. Among the virus infections, to which more than half of the space is given, rubella remains the most important cause of congenital malformations, but other infections may account for larger numbers of prematurely terminated pregnancies. The pathological and developmental features of the rubella-produced defects are discussed in considerable detail, with helpful asides on the normal functions which are interfered with. This is followed by similar, but shorter, discussions of other viral infections, and for many of these the available information remains incomplete or inconclusive (for example, cytomegaly). The remaining chapters are devoted to fetal infection caused by bacteria, fungi, and protozoa. I was somewhat shocked to find that lues is

included among the bacterial diseases, while the following chapter on protozoan parasites is given over to a discussion of malaria, trypanosomiasis, and toxoplasmosis. The final chapter presents a brief discussion of immunological problems, and the book closes with a very valuable bibliography of 31 closely printed pages. The author is not historically-minded; there is no mention of Pasteur's epochal studies on silkworm diseases or of the once so fashionable syphilitic origin of congenital malformations, but the book provides a solid basis for future work.

W. LANDAUER
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The Molecular Basis of Evolution. Christen B. Anfinsen. Wiley, New York; Chapman and Hall, London, 1959. xiii + 228 pp. Illus. $7.

In the days of multivolume encyclopedic treatises, it is refreshing to read a short book with high specific activity. The title is more descriptive of the ultimate intellectual aim of much of the work which is described than of the actual contents of the book. However, the reader will find here a concise account of current ideas about the biochemical aspects of genetics. The material is well selected, lucidly presented, and as up-to-date as can be expected. Regrettably, the index is not as detailed as it might be.

The author appears to address himself primarily to biochemists, and as a result the book serves as a most useful introduction to those aspects of genetics which are closely linked to biochemical problems or which are susceptible to biochemical analysis. After reviewing briefly general genetic and evolutionary principles, Anfinsen devotes the remainder of the work to a discussion of the functional, structural, and chemical properties of genetic material, protein structure and biosynthesis, and nucleic acid structure and biosynthesis. Instead of limiting himself to a summary of results, he has taken pains to include a description of the principles and pertinent procedural details of the experiments on which the conclusions are based. Of particular value in this connection are the references to the original papers in which the interested reader can find further information.

While acquainting biochemists with the significance of current work in genetics, Anfinsen also clarifies for geneticists much of the biochemistry with which they must deal. Thus, for instance, methods and results of investigations of protein structure are presented in a more comprehensive and at the same time more concentrated fashion than is usually available to students of genetics. Anfinsen has not hesitated to present and discuss controversial questions; such questions will be stimulating to those who are becoming acquainted with the subject. Graduate students and other readers who wish to acquaint themselves with this rapidly expanding part of biology should be especially grateful to Anfinsen for his presentation. In his preface the author states that "the writing of this book has been stimulated by the excitement and promise of contemporary protein chemistry and genetics," and it is to his credit that this excitement has been translated into print and will in turn be transmitted to his readers.

WOLF VISHNIAC
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New Books

The Actinomycetes. Nature, occurrence, and activities. vol. 1. Selman A. Waksman. Williams & Wilkins, Baltimore, Md., 1959. 338 pp. $12.50.

Die Aktivierte Essigsäure. Das coenzyme A und seine acylderivate im stoffwechsel der zelle. Karl Decker. Enke, Stuttgart, Germany, 1959. 314 pp. DM. 74.80.

Analytical Elements of Mechanics. vol. 1. Thomas R. Kane. Academic Press, New York, 1959. 265 pp. $4.75.

Anglo-America. A regional geography. Earl B. Shaw and Jameson MacFarland. Wiley, New York; Chapman & Hall, London, 1959. 487 pp. $7.75.

Annual Review of Physical Chemistry. vol. 10. H. Eyring, Ed. Annual Reviews, Palo Alto, Calif., 1959. 545 pp. $7. Contents: "Thermochemistry and thermodynamic properties of substances," J. M. Sturtevant; "Experimental molecular structure," O. Bastiansen and E. W. Lund; "The kinetics of reactions in gases," A. F. Trotman-Dickenson; "Physical and chemical properties of surfaces," J. M. Honig; "Block and graft copolymers," G. M. Burnett; "Ion exchange," H. F. Walton; "Trapped energetic radicals," J. L. Franklin and H. P. Broida; "Physical organic chemistry," V. Gold; "Proteins and synthetic polypeptides," H. A. Scheraga; "Heterogeneous equilibria and phase diagrams," R. F. Porter; "Solutions of electrolytes," J. C. Poirier; "Solutions of nonelectrolytes," G. S. Rushbrooke; "Radiation chemistry," A. Charlesby and A. J. Swallow; "Quantum theory, theory of molecular structure and valence," J. A. Pople; "Electronic spectra of organic compounds," J. R. Platt; "Vibration-rotation spectra," R. M. Hexter; "The solid state," W. J. Moore; "Nuclear and paramagnetic resonance," G. K. Fraenkel and B. Segal; "High temperature chemistry," J. L. Margrave.

The Annual Survey of Psychoanalysis. vol. 5, *1954.* John Frosch and Nathaniel Ross, Eds. International Universities Press, New York, 1959. 622 pp. $12.

Applied pharmacology (Clark). Andrew Wilson and H. O. Schild. Little, Brown, Boston, 1959. 762 pp. $10.

Atlas of γ-Ray Spectra from Radiative Capture of Thermal Neutrons. L. V. Groshev, V. N. Lutsenko, A. M. Demidov, V. I. Pelekhov. Translated from the Russian by J. B. Sykes. Pergamon, New York, 1959. 198 pp. $20.

Basic Bacteriology. Its biological and chemical background. Carl Lamanna and M. Frank Mallette. Williams & Wilkins, Baltimore, Md., ed. 2, 1959. 866 pp. $13.50.

Black Gold at Titusville. Lavinia Dobler. Dodd, Mead, New York, 1959. 186 pp. $3.

Close Binary Systems. Zdenek Kopal. Wiley, New York, 1959. 573 pp. $16.75.

Ehrenbuch der Röntegenologen und Radiologen aller Nationen. Hermann Holthusen, Hans Meyer, Werner Molineus. Von Urban and Schwarzenberg, Berlin, 1959. 268 pp. DM. 28.

Exposure Manual. J. F. Dunn. Wiley, New York, 1959. 268 pp. $7.50.

Handbook of Physiology, vol. 1, section 1, *Neurophysiology.* John Field, Ed.-in-Chief; H. W. Magoun, Section Ed.; Victor E. Hall, Exec. Ed. American Physiological Soc., Washington, D.C., 1959. 792 pp. $22.

Handbuch der Physik. vol. 3, No. 2, *Principles of Thermodynamics and Statistics.* S. Flügge, Ed. Springer, Berlin, 1959. 685 pp. DM. 160.

Plant Pathology. Problems and progress, 1908–1958. C. S. Holton, G. W. Fischer, R. W. Fulton, Helen Hart, S. E. A. McCallan. Published for the American Phytopathological Soc. by the Univ. of Wisconsin Press, Madison, 1959. 577 pp. $8.50.

Symposium on Pulmonary Ventilation. R. P. Harbord and R. Wollmer, Eds. Sherratt, Altrincham, England; Williams & Wilkins, Baltimore, Md., 1959. 109 pp. $4. The symposium was held in Leeds under the auspices of the *British Journal of Anaesthesia.* Speakers at the symposium included R. Woolmer (chairman), P. W. Ramwell, R. P. Harbord, I. Donald, T. C. Gray, P. Hugh-Jones, E. J. Morgan Campbell. Approximately 22 people participated in the symposium.

This World of Living Things. Paul Griswold Howes. Duell, Sloan and Pearce, New York, 1959. 251 pp. $4.50.

The Viruses. Biochemical, biological, and biophysical properties. vol. 2, *Plant and Bacterial Viruses.* F. M. Burnet and W. M. Stanley, Eds. Academic Press, New York, 1959. 421 pp. $13.

The Young Inventors' Guide. Raymond F. Yates. Harper, New York, 1959. 112 pp. $2.50.

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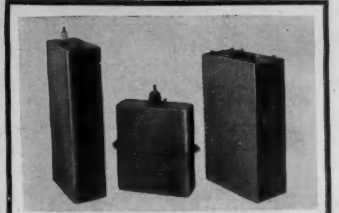

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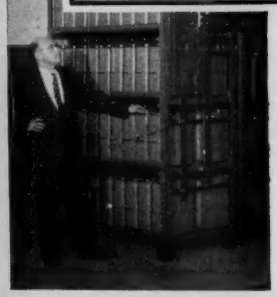

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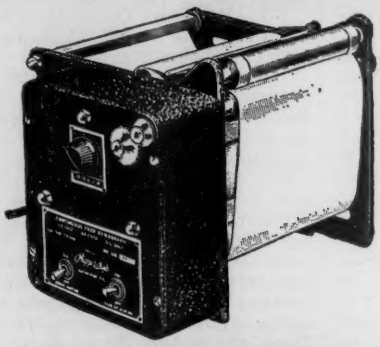

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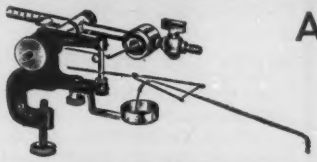

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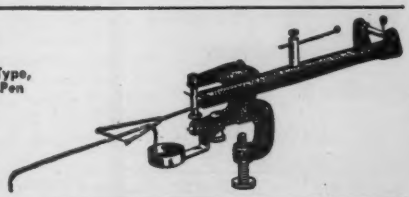

70-736
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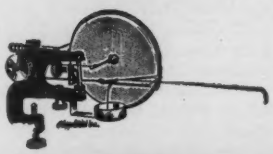

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Meetings

Forthcoming Events

November

22–24. American Soc. of Hematology, 2nd annual, St. Louis, Mo. (J. W. Rebuck, Henry Ford Hospital, Detroit, Mich.)

22–29. Pan American Child Cong., 11th, Bogotá, Colombia. (Office of Intern. Conferences, Department of State, Washington 25.)

22–29. Venezuelan Geological Cong., 3rd, Caracas. (A. R. Martínez, Jersey Production Research Co., 1133 N. Lewis Ave., Tulsa 10, Okla.)

23–24. Solid-State Techniques in Modern Instrumentation, symp., Philadelphia, Pa. (G. L. Eberly, 12 S. 12 St., Philadelphia 7.)

23-25. Fluid Dynamics (APS), Ann Arbor, Mich. (R. J. Emrich, Dept. of Physics, Lehigh Univ., Bethlehem, Pa.)

23–26. Technical European Conf. on Standards Applicable to Water (by invitation only), Copenhagen, Denmark. (World Health Organization, Regional Committee for Europe, 8 Scherfigsvej, Copenhagen.)

23–3. Inter-African Soils Conf., 3rd, Daloba, Guinea. (Committee for Technical Cooperation in Africa South of the Sahara, Abbey House, 2–8 Victoria St., London, S.W.1, England.)

25. Association for the Advancement of Psychoanalysis, New York, N.Y. (New York Acad. of Medicine, 2 E. 103 St., New York, N.Y.)

26–27. Association for the Utilization of Atomic Energy in Ship-Building and Navigation, Hamburg, Germany. (Gesellschaft für Kernenergieverwertung in Schiffbau m.b.H., Hamburg.)

26–28. Central Assoc. of Science and Mathematics Teachers, Chicago, Ill. (G. G. Mallinson, Western Michigan Univ., Kalamazoo.)

26–28. Ceylon Assoc. for the Advancement of Science, Colombo. (K. Arumugam and S. Wijesundera, General Secretaries, Univ. of Ceylon, Colombo 3.)

26–29. Legal and Administrative Problems of Peaceful Use of Nuclear Energy, intern. conf., Rio Piedras, Puerto Rico. (J. Mayda, Faculty of Law, Univ. of Puerto Rico, Rio Piedras.)

27–28. American Mathematical Soc., Detroit, Mich. (J. W. Green, Univ. of California, Los Angeles 24.)

27–28. American Physical Soc., Cleveland, Ohio. (K. K. Darrow, Columbia Univ., New York 27.)

27–28. American Soc. of Animal Production, Chicago, Ill. (H. H. Stonaker, Colorado State University, Fort Collins.)

27–28. National Council for Geographic Education, Detroit, Mich. (L. Kenndmer, Univ. of Texas, Austin.)

27–17. Bahamas Medical Conf. Nassau. (B. L. Frank, Box 4037, Fort Lauderdale, Fla.)

29–30. American College of Chest Physicians, Dallas, Tex. (M. Kornfield, 112 E. Chestnut St., Chicago 11, Ill.)

29–4. American Soc. of Mechanical Engineers, annual, Atlantic City, N.J. (ASME, 29 W. 39 St., New York 18.)

30–2. American Acad. for Cerebral Palsy, 13th annual, Los Angeles, Calif. (G. L. Brooks, AACP, Brown Univ., Providence 12, R.I.)

30–2. French-Speaking Neurosurgeons Society, annual, Paris, France. (M. David, 4, rue Galliera, Paris.)

30–3. Eastern Joint Computer Conf., Boston, Mass. (Miss M. Fox, EJCC, Box 4999, Washington 8.)

30–3. Entomological Soc. of America (joint with the societies of Canada and Ontario), annual, Detroit, Mich. (L. L. Reed, Entomological Soc. of Canada, Science Service Building, Ottawa, Canada.)

30–16. Tropical Meteorology, symp., Nairobi, Kenya, East Africa. (Secretariat, World Meteorological Organization, Campagne Rigot, Avenue de la Paix, Geneva, Switzerland.)

30–17. Problems of Tropical Meteorology in Africa and the Neighboring Islands, symp., Nairobi, Kenya, Africa. (World Meteorological Organization, Campagne Rigot, 1, Avenue de la Paix, Geneva, Switzerland.)

December

1–3. Eastern Joint Computer Conf., Boston, Mass. (D. T. Ross, Dept. of Electrical Engineering, Massachusetts Inst. of Technology, Cambridge.)

1–4. American Medical Assoc. (clinical), Dallas, Tex. (R. M. McKeown, 510 Hall Bldg, Coos Bay, Oreg.)

2–4. Electrical Furnace Conf., Cleveland, Ohio. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

3–4. Semiconductor Surfaces, 2nd conf., Silver Spring, Md. (R. F. Greene, U.S. Naval Ordnance Lab., White Oak, Silver Spring, Md.)

3–4. Vehicular Communications, St. Petersburg, Fla. (L. G. Cumming, IRE, 1 E. 79 St., New York 21.)

3–5. Corrosion, symp., Dresden, Germany. (Chemische Gesellschaft in der Deutschen Demokratischen Republik, Unter den Linden 68/70, Berlin W.8, Germany.)

3–5. Visual Communications, 3rd annual intern. conf., New York, N.Y. (E. Kaestner, Soc. of Reproductive Engineers, Bell Telephone Labs., New York, N.Y.)

3–11. Training and Education in Nutrition, European symp., Frankfurt am Main, Germany. (Food and Agricultural Organization of the United Nations, Viale delle Terme di Caracalla, Rome, Italy.)

3–12. International Confederation of Free Trade Unions, 7th world cong., Brussels, Belgium. (ICFTU, 24, rue du Lombard, Brussels.)

4–6. American Psychoanalytic Assoc., New York, N.Y. (D. Beres, 151 Central Park West, New York 23.)

5–10. American Acad. of Dermatology and Syphilology, Chicago, Ill. (R. R. Kierland, First National Bank Bldg., Rochester, Minn.)

6. American Acad. of Dental Medicine, mid-annual, New York, N.Y. (A. J. Cannistraci, 2152 Muliner Ave., New York 62.)

6–10. American Inst. of Chemical Engineers, annual, San Francisco, Calif. (F. J. Van Antwerpen, AICE, 25 W. 45 St., New York 36.)

(See issue of 16 October for comprehensive list)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science nor the writer assumes responsibility for the accuracy of the information. A coupon for use in making inquiries concerning the items listed is included in the post card insert.

▪ ELECTRONIC MULTIPLIER is capable of performing four-quadrant multiplication of two electrical signals. Bandwidth is d-c to 10 kcy/sec. A meter and reference voltage are provided to facilitate balance and calibration. The meter also provides indication of any average product term such as average power. The multiplier features high-impedance input and low-impedance, push-pull output. (Potential Inc., Dept. 135)

▪ DIGITAL CLOCK furnishes output in the form of contact closures representing hours, minutes, and seconds. Output can be in decimal, binary, or binary-coded-decimal form. Visual readout is obtained by means of an in-line digital display. Timing accuracy depends on the frequency accuracy of the supply power. Individual time-set buttons are provided for each digit. Zero reset is also provided. (Datex Corp., Dept. 136)

▪ INVERTER for conversion of d-c to a-c uses silicon semiconductor and magnetic components with no moving parts. Specifications are: output range, to 3 kva; frequency stability, ±0.5 to ±0.002 percent; output voltage regulation, ±3 percent; input voltage tolerance, 22 to 30 volts; overload tolerance, 300 percent; harmonic content, < 5 percent. Operating temperatures up to 250°F are permitted. (Borg-Warner Corp., Dept. 152)

▪ NOISE SIGNAL SOURCE for the frequency range 3 to 500 Mcy/sec employs type 5722 diodes as noise source. Noise figure from 0 to 19 db is covered in two ranges. Accuracy is said to be ±0.5 db over the entire frequency range and over the entire dial scale. Voltage-standing-wave ratio is less than 1.2 over the frequency range given. Output impedance is 50 ohms unbalanced. (New London Instrument Co., Dept. 160)

▪ PROGRAMMABLE POWER SUPPLY is designed to furnish voltages from a programmed source, such as a magnetic-tape reader or punched card, or by manual push-button selection. Regulation is 0.1 percent, no load to full load, and accuracy is said to be ±0.1 percent. Ranges of three models are 6 to 36 v in 0.1-v steps at 30 amp; 1 to 500 v in 1-v steps at 1 amp; 0 to 99.9 v in 0.1-v steps at 1.5 amp. Three

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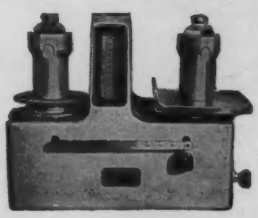
SMALL ANIMAL BALANCE

Model 4203B-TC-SA recommended for fast, precise weighing of mice, chicks, frogs and small rats. Dial graduated in two columns: 0—30 grams and 15—45 grams in increments of 0.5 gram. Dial shutter with outside control to close off dial column not in use. Beam 100 grams by 1 gram. Other models up to 3 kilos, 350 milligram sensitivity for rats, hamsters and guinea pigs.

CENTRIFUGE BALANCE

Model 4206B-TC also for general laboratory use and small-animal weighing. Has tare control knob to zero the dial, or position for over-and-under reading. Capacity 3 kilos; sensitivity to 350 milligrams. Dial is graduated 0-100 grams in increments of 1 gram. Beam 500 grams by 5 grams.



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■ RESILIENCY TESTER for polymeric materials consists of a Vicat-type penetrating-needle test unit, a regulated power supply for needle motion transducer, and a millivolt strip-chart recorder for plotting penetration and elastic recovery. The tester can measure materials of thickness from 0.7 to 125 mil. (Thwing-Albert Instrument Co., Dept. 153)

■ HIGH VACUUM SYSTEM is said to attain pressure of 10^{-9} mm-Hg within a work chamber 12-in. in diameter and 18-in. high. The work chamber, of stainless steel, is equipped with two 2-in. diameter windows and rotary-motion and electrical feed-throughs. An outer chamber surrounding the work chamber is pumped to 10^{-5} mm-Hg. The outer chamber is fitted with heating elements, radiation shields, and cooling coils and has observation ports conforming to those of the work chamber. (Kinney Manufacturing, Dept. 149)

■ CATHODE-RAY TUBES offer resolutions up to 2000 lines per inch. Three screen sizes and three screen phosphor characteristics are available. The latter offer blue or near ultraviolet spectral colors and short or very short persistence. The tubes are said to be as rugged as standard oscilloscope tubes. Interchangeable yoke, focus coil, and video driver stage to provide maximum resolution can be supplied. (CBS-Hytron, Dept. 140)

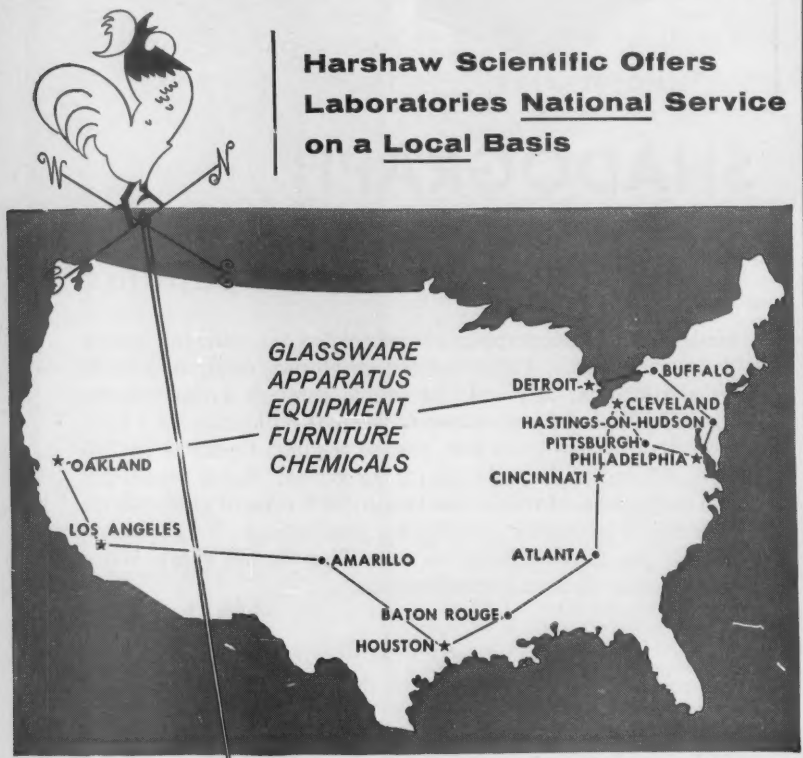
■ THERMAL TIME DELAY operates under vibration of 20 grav up to 2000 cy/sec and under shock of 50 grav for 11 msec. Delay ranges of 3 to 60 sec are available. Setting accuracy is ±5 percent, and the effects of ambient temperature are said to be held to ±5 percent over the range −65° to +125°C. Contacts are single-pole, single-throw, either normally open or normally closed. (G-V Controls, Inc. Dept. 141)

■ RADIOACTIVITY SIMULATOR, for training personnel in decontamination and handling of radioactive material, acts on simple nontoxic powders and liquids to produce effects identical with those produced by radioactive materials that can be registered on standard radioactivity detection devices such as Geiger counters, scalers, and ratemeters. (Tracerlab, Dept. 151)

■ POWER SUPPLY covers two ranges, 1000 to 5000 v and 1000 to 25,000 v, with continuous adjustability within each range. Resetting accuracy is said to be ±5 and ±3 v in the high and low ranges, respectively. Corresponding stabilities are ±6 and ±4 v. Noise and ripple are less than 25 mv r.m.s. Current of 100 μa is available up to 3000 v. (Technical Measurements Corp., Dept. 156)

■ SIGNAL GENERATOR includes three oscillators, all operating in the 20-40 Mcy/sec range, providing two continuous-wave outputs and one swept signal. Width of the swept-frequency signal may be varied from 0.05 to 40 percent of the center frequency. At maximum sweep width the output signal is constant within 0.25 db. Sweep rate is determined by line frequency. Frequency markers are added to the signal after it has passed through the circuit under test. (Telonic Industries, Dept. 158)

■ SPECTRUM ANALYZERS for airborne use are designed to analyze high-frequency vibration signals before these are telemetered. The analyzers operate by sweeping through the spectrum of signals with a narrow-band filter. Frequency ranges of three models are 100 to 2000, 300 to 10,000, and 25 to



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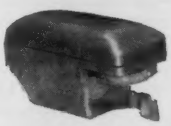

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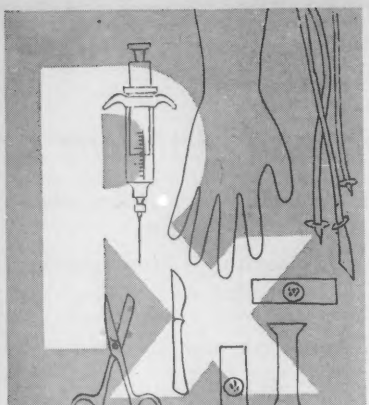

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And *completely* clean means the absence of soil and residual cleanser material.
And that's the kind of cleanliness you get, *every time*, with HAEMO-SOL.
HAEMO-SOL removes solids, such as oils, fats, blood, scum, pus, milk, food and biologicals.
HAEMO-SOL softens water.
Prevents scale.
HAEMO-SOL does not etch glassware, rust metal, soften rubber or attack plastics. Its low concentration, ½ oz. per gallon, means fast economical cleansing without guesswork.

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If the laboratory, central service or surgery hasn't learned about HAEMO-SOL, write for literature, and for free sample. For pressure washer, request HAEMO-SOL "N.S." (Non-Sudsing).

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300 cy/sec. Sweep period is adjustable from 1 to 22 sec. Two frequency markers, one for zero frequency, are provided in each range. Input signal amplitude is 1.75 v r.m.s.; output 0 to 5 v. Input impedance is 50,000 ohms, maximum; output impedance 10,000 ohms maximum. Size is less than 25 in.^{3} and weight less than 16 oz. (Gulton Industries, Dept. 159)

■ OSCILLOSCOPE CAMERA designed for 5-in. cathode-ray tubes provides continuous records on photosensitive paper. Continuous viewing is possible while the camera is operating. Two interchangeable gears provide ranges of speed ¼ to 17 in./sec and 5 to 275 in./sec, respectively. Lens is $f/1.8$, 90-mm focal length. (Hamilton Watch Co., Dept. 157)

■ ARC IMAGING FURNACE combines a blown, high-intensity arc with an optical-bench system for reimaging the radiant energy onto a sample. The optical system uses an ellipsoidal projection mirror and an ellipsoidal imaging mirror. Diameter of the image spot is 9 mm. The system can be operated with the reimaging-mirror axis horizontal or vertical, the latter orientation permitting use of a sample in a crucible. Temperatures up to 3850°K are reported by the manufacturer. Available accessories include absolute irradiance colorimeters, incident radiation shutters, alternative focal-length collecting mirrors, and miniature foil-type radiometers. (Arthur D. Little, Dept. 163)

■ MANOMETER provides digital indication through a pickup that produces a frequency-modulated output in response to pressure changes. The pickup operates by the effect of pressure in changing the tension of a vibrating wire. The wire vibrates in a magnetic field and is used as the frequency-determining element of an electric circuit. The output is fed into an electronic display counter. Pressure range is 0 to 10,000 lb/in^2. Response time for full-scale reading is approximately 3 sec. The pickup may be remote from the counter. (Borg-Warner Corp., Dept. 165)

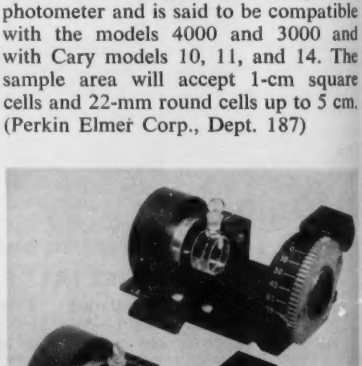
■ SPEED CHANGER KIT permits assembly of 29 speed ratios from parts that may be used repeatedly in different combinations. Ratios from 1:1 to 44:1 are provided. Torques up to 130 oz-in. at the low-speed shaft and speeds up to 10,000 rev/min are handled. (Metron Instrument Co., Dept. 167)

■ PERFORATED-TAPE PROGRAMMER features bi-directional drive, reading rates up to 200 characters per second, tape widths up to 1 in., and self-contained electronic circuitry for control and data playback. Capacity is 500 ft of Mylar tape or 300 ft of paper tape. Input power is 28-volt d-c or 115-volt, 400-cy/sec a-c. (Potter Instrument Co., Dept. 161)

■ LABORATORY CALCINER provides continuous heating and subsequent cooling in a controlled atmosphere. The inside dimensions of the rotating tube furnace are 6.5 in. (diameter) and 28 in. (length). Temperatures up to 2000°F can be provided, with cooling to 150° to 2000°F. Bellows seals permit pressures up to 2 in. (water) to be maintained, with gas flow in either direction. Electric or gas-fired models are available. (C. O. Bartlett & Snow Co., Dept. 174)

■ ELECTRIC TUBE FURNACE for temperatures up to 2800°F is gas tight; a 5-in. diameter Mullite tube, with silicon carbide heating elements, is used. The hot zone, 30 in. long, is divided into three zones, each separately heated. Rubber-gasketed metallic seals are used at both ends of tube. The loading end is provided with a preheat zone, and the unloading end is water-jacketed. Provision is made for vacuum connection. Over-all length is 60 in. (Pereny Equipment Co., Dept. 173)

■ ROTARY DISPERSION ATTACHMENTS may be substituted for the sample holders in a double-beam spectrophotometer to convert the latter into a recording polarimeter. The attachments comprise a fixed, alignable, polarizing calcite prism, a sample area, and a calcite analyzer prism. The latter is adjustable in increments of 5 deg with reproducibility ±0.01 deg. Wavelength range of calcite available is 240 to 2700 μ. The accessory is designed for use with the manufacturer's model 4000-A spectrophotometer and is said to be compatible with the models 4000 and 3000 and with Cary models 10, 11, and 14. The sample area will accept 1-cm square cells and 22-mm round cells up to 5 cm. (Perkin Elmer Corp., Dept. 187)



▪ ANALOG MULTIPLIER is a Hall effect generator featuring linearity better than 1 percent over an output range 100,000 to 1. The units, manufactured of indium arsenide and indium antimonide, are said to have low temperature coefficients, high accuracy and repeatability, and excellent high frequency properties. They are available with or without magnetic field coils. (Device Development Corp., Dept. 164)

▪ TESTING MACHINE features separation of the loading frame from the control console, thus allowing in-cell testing of irradiated materials. Load ranges are selectable remotely over a 50-to-1 range, crosshead speeds over a 1000-to-1 range. Calibration can be performed remotely by means of a built-in 100-lb weight. Air-operated grips facilitate loading. (Instron Engineering Corp., Dept. 166)

▪ LIQUID DETECTOR consists of a probe, amplifier, and connecting cable. If the probe is inserted into a vessel or transfer line, any liquid present fills the space between concentric cylinders of the probe, producing an increase in capacitance. Liquid level can be measured within 1/16 in. The probe will withstand pressure of 250 lb/in.^{2} at –297°F and liquid velocity of 18 ft/sec. (Minneapolis-Honeywell Regulator Co., Dept. 169)

▪ FILM PROCESSER handles automatically up to 1000 ft of 16- or 35-mm oscilloscope recording film or paper. Film is transported at a rate of 5 ft/min through developing, rinse, fixing, second rinse, hypo eliminator, washing, and drying. Developing time is adjustable from 1 to 2 min. (Electronic Tube Corp., Dept. 168)

▪ AUTOCLAVE for bench-scale operations has capacity of 300 ml and 5000 lb/in.^{2} (gage). Stirrer shaft speeds up to 1500 rev/min can be used. Several stirrers are available. Up to six openings can be provided in the body flange. A spiral-grooved jacket permits rapid heating and cooling. Electric heating can be supplied. The dimensions are 20 by 12 by 26 in. (Pressure Products Industries, Inc., Dept. 150)

▪ SURGICAL STEREOSCOPIC MICROSCOPE is attached to a heavy stand consisting of an adjustable vertical pillar and horizontal arm. The entire unit moves on locking ball-bearing casters. When the microscope is in focus, the distance between the observed area and the objective is 8 in. (American Optical Co., Dept. 172)

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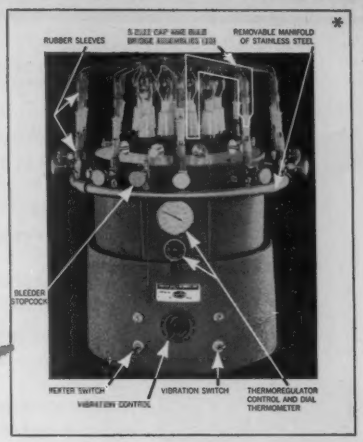
National Bureau of Standards, Washington, D.C.

EVAPORATE MULTIPLE FRACTION CUTS DIRECTLY FROM TEST TUBES IN 10-20 MINUTES!

New!

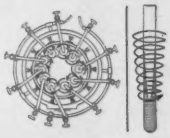
Rotary Evapo-Mix

For the rapid and simultaneous evaporation under controlled temperature and vacuum of samples collected from a chromatographic column, centrifuge tubes, or by solvent extraction.



FEATURES

- Controlled circular vibration creates deep swirling to prevent "bumping" during heating under vacuum.



vortex created by eccentric motion of unit

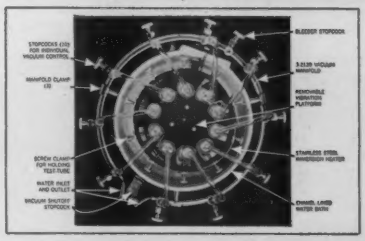
Arrows indicate eccentric motion of unit

- Internal variable voltage transformer controls vibration rate.
- Simultaneously evaporates 10 test tubes or centrifuge tubes, 16-25 mm diameter.
- Connects to efficient water aspirator as vacuum source.
- Automatic thermoregulator controls temperature of water bath.
- Price complete **$436.00**

With the Rotary Evapo-Mix it is possible to achieve in a single test tube evaporation rates of water of 1.0 ml/min; ethonal, 4.2 ml/min; methonal, 4.5 ml/min; ethyl acetate, 7.2 ml/min; and for acetone 10.0 ml/min; with all 10 test tubes attached, evaporation rate decreases approximately 25%.

• Vacuum Manifold only, made of pyrex-brand glass also available.

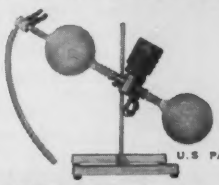
Request Bulletin 3-2100 for complete details.



FLASH EVAPORATORS

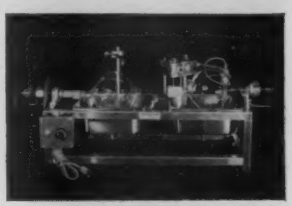
For the evaporation of aqueous solutions, high boiling point solvents, strong acids, alkalis and radiactive materials without contaminating back-drip.

PORTABLE MODEL



U.S PATENT 2,865,445

FEATURES • Glass-to-glass connections throughout the evaporating system prevent any possibility of contamination. Distillation occurs only within glass. • Balanced design permits smooth rotation without drag and larger output without loss of material. • High torque, totally enclosed motor. • Build it up with accessories for large scale work and temperature control. • Grows with your requirements. • Unit can be easily taken apart for cleaning. • Prices start from $148.45.



U.S. PATENT 2,865,443

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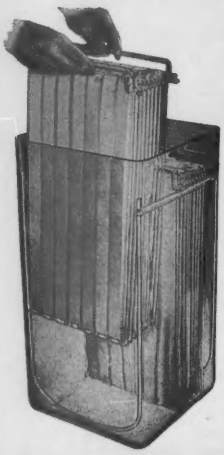

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DIRECTORY OF ADVERTISED PRODUCTS

Classified in the following pages are the products advertised in *Science* in the issues from 24 October 1958 through 25 September 1959. This list is intended to aid laboratory workers in finding the manufacturers of all types of laboratory equipment and supplies. At the end of the classified list is a list of companies that advertised in "The Market Place" section during the period 24 October 1958 through 25 September 1959. An index of advertisers in this issue appears on page 1152.

ABSORPTION CELLS

American Instrument Co., Inc.
1959: 22 May, 1439
Klett Manufacturing Co.
1958: 24 Oct., 1027; 31 Oct., 1096; 7 Nov., 1159; 14 Nov., 1225; 21 Nov., 1286; 28 Nov., 1351; 5 Dec., 1445; 12 Dec., 1520; 19 Dec., 1586; 26 Dec., 1631
1959: 2 Jan., 47; 9 Jan., 106; 16 Jan., 158; 23 Jan., 228; 30 Jan., 278; 6 Feb., 345; 13 Feb., 400; 20 Feb., 522; 27 Feb., 574; 6 Mar., 670; 13 Mar., 728; 20 Mar., 788; 27 Mar., 846; 3 Apr., 912; 10 Apr., 976; 17 Apr., 1032; 24 Apr., 1159; 1 May, 1235; 8 May, 1298; 15 May, 1368; 22 May, 1442; 29 May, 1497; 5 June, 1558; 12 June, 1626; 19 June, 1685; 26 June, 1752; 3 July, 55; 10 July, 114; 17 July 175; 24 July, 234; 31 July, 279; 7 Aug., 346; 14 Aug., 400; 21 Aug., 468; 28 Aug., 508; 4 Sept., 578; 11 Sept., 643; 18 Sept., 747; 25 Sept., 804

AMPLIFIERS

American Electronic Laboratories, Inc.
1959: 25 Sept., 804
Borg-Warner Corp., BJ Electronics
1958: 12 Dec., 1519
Donner Scientific Co.
1959: 20 Feb., 509; 6 Mar., 671; 3 Apr., 907; 5 June, 1560
Eldorado Electronics
1958: 24 Oct., 1010
1959: 20 Feb., 506
Houston Instrument Corp.
1959: 29 May, 1499
Packard Instrument Co., Inc.
1958: 26 Dec., 1636
1959: 9 Jan., 68; 23 Jan., 178
Philbrick, George A., Researches, Inc.
1959: 20 Feb., 425
Technical Measurement Corp.
1959: 6 Mar., 612
Texas Instruments, Inc.
1958: 24 Oct., 940

ANALYZERS

Advanced Instruments, Inc
1958: 24 Oct., 1032
Beckman Instruments, Inc., Spinco Div.
1958: 19 Dec., 1530
1959: 20 Feb., 410; 19 June, 1634; 28 Aug., 474
Kruger, Harold, Instruments
1958: 19 Dec., 1583
Phoenix Precision Instrument Co.
1959: 20 Feb., 420; 6 Mar., 602
Research Specialties Co.
1959: 20 Mar., 792
Technicon Chromatography Corp.
1959: 18 Sept., 733

ANALYZERS, PULSE-HEIGHT

Eldorado Electronics
1958: 24 Oct., 1047
1959: 15 May, 1326; 26 June, 1700
Picker X-Ray Corp.
1959: 12 June, 1575
Technical Measurement Corp.
1959: 16 Jan., 120; 6 Mar. 612; 3 July, 6; 14 Aug., 362; 18 Sept., 676
Victoreen Instrument Co.
1959: 21 Aug., 461

ANIMALS, EXPERIMENTAL

Cumberland View Farms
1959: 26 June, 1758; 14 Aug., 406
Holtzman Co.
1959: 30 Jan., 286; 27 Feb., 582; 26 June, 1758; 10 July, 118
Sprague-Dawley, Inc.
1958: 5 Dec., 1382

ASEPTIC DISPERSER

Waring Products Corp.
1958: 24 Oct., 1014

BALANCES, ANALYTICAL

Ainsworth, Wm., & Sons, Inc.
1958: 21 Nov., 1295
Brinkmann, C. A., & Co., Inc.
1958: 5 Dec., 1471
1959: 20 Feb., 499; 27 Mar., 849
Cahn Instrument Co.
1959: 24 Apr., 1173
Exact Weight Scale Co.
1958: 24 Oct., 1025; 5 Dec., 1459
1959: 16 Jan., 157; 20 Feb., 491; 20 Mar., 787; 15 May, 1371; 18 Sept., 725
Fisher Scientific Co.
1958: 24 Oct., 949
1959: 11 Sept., 639
Mettler Instrument Corp.
1958: 24 Oct., 956
1959: 20 Feb., 412; 24 Apr., 1069; 18 Sept., 656
Ohaus Scale Corp.
1958: 24 Oct., 1040
Sauter, August, of New York, Inc.
1959: 18 Sept., 720
Scientific Glass Apparatus Co., Inc.
1959: 23 Jan., 218; 20 Feb., 504
Standard Scientific Supply Corp.
1959: 21 Aug., 462
Thomas, Arthur H., Co.
1959: 9 Jan., 112
Torsion Balance Co.
1958: 24 Oct., 945
1959: 20 Feb., 431; 6 Mar., 611; 24 Apr., 1070; 26 June, 1701; 24 July, 191; 18 Sept., 671
Welch, W. M., Manufacturing Co.
1959: 3 Apr., 909; 4 Sept., 577
Will Corp.
1959: 6 Mar., 668

BALANCES, ANIMAL

Exact Weight Scale Co.
1958: 24 Oct., 1025; 5 Dec., 1459
1959: 16 Jan., 157; 20 Feb., 491; 20 Mar., 787; 15 May, 1371; 18 Sept., 725

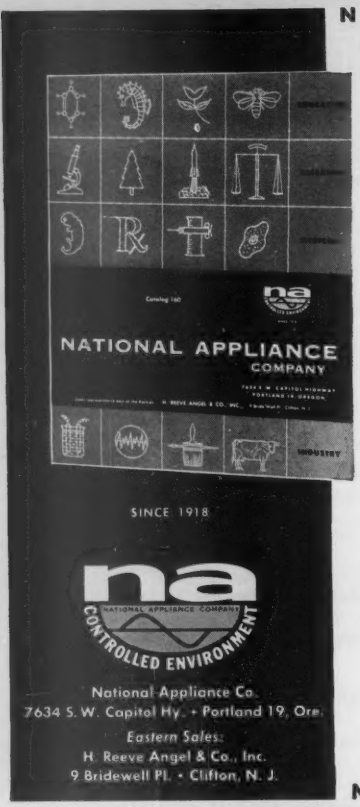
BATHS

Phipps and Bird, Inc.
1959: 17 Apr., 1035
Sargent, E. H., & Co.
1958: 28 Nov., 1307
1959: 17 Apr., 989

BOOKS AND JOURNALS

Academic Press, Inc.
1958: 24 Oct., 1024
1959: 30 Jan., 277; 6 Mar., 659; 24 Apr., 1149
Acta, Inc.
1958: 5 Dec., 1463
Addison-Wesley Publishing Co., Inc.
1958: 5 Dec., 1441
1959: 24 Apr., 1141
American Fisheries Society
1959: 24 Apr., 1160
American Institute of Biological Sciences
1958: 14 Nov., 1231
1959: 2 Jan., 55
Annual Reviews, Inc.
1958: 24 Oct., 1019; 14 Nov., 1223; 5 Dec., 1464
1959: 9 Jan., 103; 20 Feb., 510; 6 Mar., 661; 24 Apr., 1144; 8 May, 1299; 12 June, 1625; 10 July, 111; 7 Aug., 346; 4 Sept., 580
Basic Books
1958: 5 Dec., 1367
1959: 13 Feb., 401; 13 Mar., 727; 24 Apr., 1057; 15 May, 1370
Beacon Press
1958: 26 Dec., 1632
Biological Laboratory, Cold Spring Harbor, N.Y.
1958: 19 Dec., 1588
British Information Services
1958: 24 Oct., 1040
1959: 20 Feb., 512b; 6 Mar., 652; 24 Apr., 1174
Cambridge University Press
1959: 24 Apr., 1155
Columbia University Press
1958: 5 Dec., 1452
Consultants Bureau, Inc.
1958: 7 Nov., 1152, 1158; 26 Dec., 1630
1959: 30 Jan., 279; 20 Feb., 500; 24 Apr., 1061; 31 July, 283; 14 Aug., 394
Cranbrook Institute of Science
1958: 5 Dec., 1445
Doubleday & Co., Inc.
1959: 24 Apr., 1156; 18 Sept., 660
Dover Publications, Inc.
1958: 31 Oct., 1055
1959: 9 Jan., 61; 20 Mar., 790; 3 Apr., 860
Dutton, E. P., & Co.
1959: 24 Apr., 1160
Garfield, Oliver, Co., Inc.
1959: 6 Feb., 291
Harvard University Press
1959: 20 Feb., 512a; 12 June, 1576
Hoeber, Paul B., Inc.
1959: 24 Apr., 1048
Houghton, Mifflin Co.
1959: 24 Apr., 1173

NATIONAL APPLIANCE



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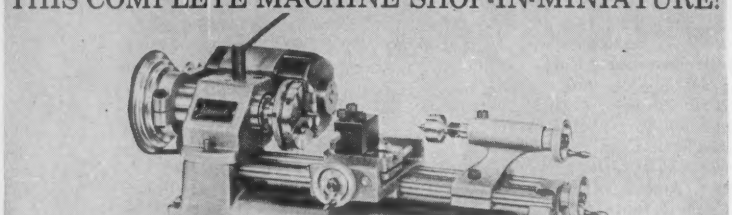

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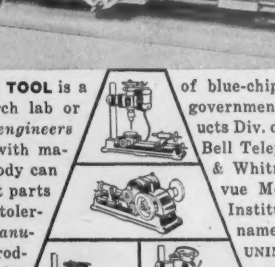

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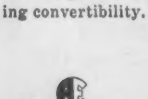

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Interlanguage Dictionaries Publishing Corp.
1958: 5 Dec., 1442
Interscience Publishers, Inc.
1959: 24 Apr., 1163
Johns Hopkins Press
1958: 19 Dec., 1583
Journal of Lipid Research
1959: 6 Mar., 594
Lea & Febiger
1958: 5 Dec., 1460
1959: 24 Apr., 1139
Library of Science
1958: 14 Nov., 1172
1959: 9 Jan., 66; 3 Apr., 863; 1 May, 1189; 11 Sept., 591
Lippincott, J. B., Co.
1959: 24 Apr., 1146; 1 May, 1233; 22 May, 1438; 31 July, 281
Macy, Josiah, Jr. Foundation
1958: 5 Dec., 1466
McGraw-Hill Book Co., Inc.
1959: 24 Apr., 1064, 1065; 19 June, 1681
Mosby, C. V., Co.
1959: 24 Apr., 1067
Natural History Book Club
1959: 6 Mar., 591; 7 Aug., 292
Old Secretariat, Publications Div., Delhi
1958: 12 Dec., 1520; 19 Dec., 1586
Optical Society of America
1959: 26 June, 1746; 3 July, 46; 10 July, 112; 4 Sept., 578; 11 Sept., 636; 18 Sept., 724; 25 Sept., 806
Oxford University Press, Inc.
1958: 5 Dec., 1446
1959: 20 Feb., 506; 24 Apr., 1152, 1164; 11 Sept., 638
Pergamon Press
1958: 24 Oct., 948
1959: 20 Feb., 422; 24 Apr., 1179; 4 Sept., 524
Philosophical Library
1958: 5 Dec., 1388; 12 Dec., 1521
1959: 13 Feb., 399; 27 Feb., 576; 24 Apr., 1166
Plenum Press, Inc.
1959: 24 Apr., 1156
Prentice-Hall, Inc.
1958: 14 Nov., 1225
1959: 24 Apr., 1047
Princeton University Press
1959: 11 Sept., 640
Reinhold Publishing Corp.
1959: 17 July, 126
Ronald Press Co.
1958: 26 Dec., 1629
1959: 13 Mar., 730; 24 Apr., 1168b; 5 June, 1512; 19 June, 1688
Saunders, W. B., Co.
1958: 7 Nov., 1103; 21 Nov., 1236; 5 Dec., 1363
1959: 2 Jan., 3; 20 Feb., 411; 6 Mar., 587; 3 Apr., 867; 17 Apr., 1031; 24 Apr., 1043; 1 May, 1190; 8 May, 1243; 15 May, 1318; 22 May, 1395; 5 June, 1507; 3 July, 3; 14 Aug., 355; 11 Sept., 587
Society for General Systems Research
1959: 27 Feb., 578
Springer Verlag
1959: 31 July, 279
United Nations Sales & Circulation (Atomic Energy)
1959: 24 Apr., 1068
University of Chicago Press
1959: 20 Mar., 742
University of Wisconsin Press
1958: 14 Nov., 1220
1959: 15 May, 1308

Van Nostrand, D., Co., Inc.
1959: 24 Apr., 1053
Wiley, John, & Sons, Inc.
1958: 5 Dec., 1376, 1377
1959: 13 Feb., 355; 13 Mar., 683; 24 Apr., 1050, 1051
Williams & Wilkins Co.
1959: 24 Apr., 1071

CAGES, ANIMAL

Maryland Plastics, Inc.
1959: 3 Apr., 864; 15 May, 1380; 18 Sept., 736
Thomas, Arthur H., Co.
1959: 7 Aug., 352

CALORIMETERS

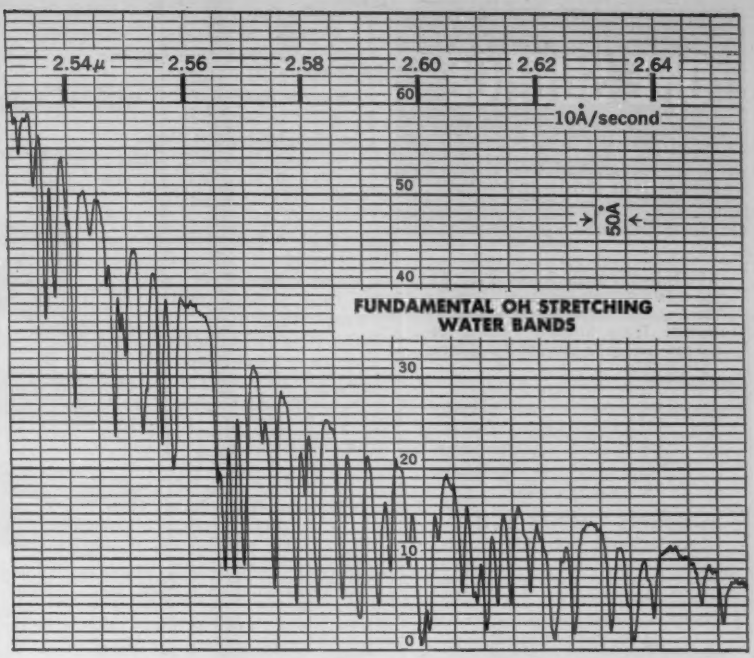
Parr Instrument Co.
1958: 24 Oct., 1027

CAMERAS AND ACCESSORIES

American Optical Co.
1958: 24 Oct., 1052
1959: 30 Jan., 288; 27 Feb., 584; 27 Mar., 856
Avco Corp.
1959: 18 Sept., 675

CATALOGS

Baker, J. T., Chemical Co.
1959: 18 Sept., 678
Bausch & Lomb Optical Co.
1958: 24 Oct., 968; 7 Nov., 1110
1959: 2 Jan., 6; 27 Feb., 536; 13 Mar., 688; 24 Apr., 1074; 22 May, 1402; 5 June, 1518; 19 June, 1642; 28 Aug., 476; 25 Sept., 762
Bel-Art Products
1959: 20 Feb., 497
California Corporation for Biochemical Research
1958: 24 Oct., 959
Cole-Parmer Instrument and Equipment Co.
1959: 18 Sept., 733
Colorado Serum Co.
1958: 24 Oct., 1023; 5 Dec., 1449
1959: 20 Feb., 522; 24 Apr., 1151; 15 May, 1385; 12 June, 1625
Corning Glass Works
1959: 13 Mar., 727; 5 June, 1515; 10 July, 115; 7 Aug., 291; 11 Sept., 640
Dimco-Gray Co.
1958: 5 Dec., 1441
Doerr Glass Co.
1959: 30 Jan., 239; 20 Feb., 423
Duralab Equipment Corp.
1959: 15 May, 1383
Eastern Industries, Inc.
1959: 13 Mar., 728; 17 July, 176
Edmund Scientific Co.
1959: 11 Sept., 592
Falcon Plastics Co.
1959: 5 June, 1509; 25 Sept., 759
Fisher Scientific Co.
1958: 12 Dec., 1518
Harvard Apparatus Co., Inc.
1959: 16 Jan., 167; 6 Mar., 673; 24 Apr., 1176
Kewaunee Manufacturing Co.
1958: 28 Nov., 1355
1959: 21 Aug., 416
Kontes Glass Co.
1959: 20 Mar., 746; 17 Apr., 992; 29 May, 1499; 19 June, 1690; 18 Sept., 728



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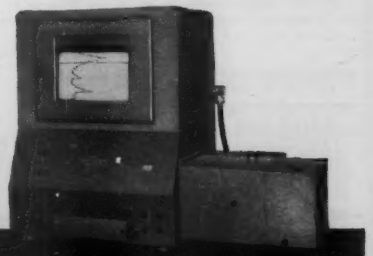

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Labline, Inc.
1959: 15 May, 1324
Laboratory Furniture Co., Inc.
1958: 24 Oct., 1022
Lafayette Radio Co.
1959: 18 Sept., 736
Lourdes Instrument Corp.
1958: 24 Oct., 963; 5 Dec., 1381
1959: 6 Mar., 653; 24 Apr., 1147; 15 May, 1375; 26 June, 1749
Matheson Co., Inc.
1959: 9 Jan., 104; 19 June, 1686; 31 July, 276
Metalab Equipment Co.
1959: 26 June, 1755
Micro-Ware, Inc.
1958: 5 Dec., 1462
Millipore Filter Corp.
1959: 20 Feb., 517; 27 Mar., 851
New England Nuclear Corp.
1959: 12 June, 1626; 26 June, 1752; 14 Aug., 400
Nuclear-Chicago Corp.
1959: 26 June, 1760
Nutritional Biochemicals Corp.
1958: 24 Oct., 1016; 7 Nov., 1155; 21 Nov., 1289; 5 Dec., 1467; 19 Dec., 1586
1959: 2 Jan., 45; 16 Jan., 155; 30 Jan., 278; 13 Feb., 400; 6 Mar., 661; 13 Mar., 728; 20 Mar., 739; 3 Apr., 859; 17 Apr., 987; 1 May, 1187; 15 May, 1307; 29 May, 1451; 12 June, 1571; 26 June, 1699; 10 July, 59; 24 July, 187; 7 Aug., 291; 21 Aug., 411; 4 Sept., 523; 18 Sept., 651
Pabst Laboratories
1959: 5 June, 1556; 31 July, 283
Palo Laboratory Supplies, Inc.
1959: 6 Mar., 661
Precision Scientific Co.
1959: 12 June, 1578
Research Specialties Co.
1959: 12 June, 1627
Sanborn Co., Medical Div.
1958: 5 Dec., 1374
1959: 9 Jan., 65; 6 Feb., 351; 6 Mar., 607; 24 Apr., 1060
Schleicher, Carl, & Schuell Co.
1959: 19 June, 1682
Science Materials Center
1959: 20 Feb., 413
Scientific Glass Apparatus Co., Inc.
1959: 15 May, 1309; 11 Sept., 634
Schwarz Laboratories, Inc.
1959: 15 May, 1383; 29 May, 1495
Sorvall, Ivan, Inc.
1958: 24 Oct., 933; 5 Dec., 1373
Tracerlab, Inc.
1959: 10 Apr., 929; 21 Aug., 468; 25 Sept., 808
United Scientific Co.
1958: 24 Oct., 1051; 31 Oct., 1095; 21 Nov., 1243; 19 Dec., 1587
1959: 6 Feb., 342; 27 Feb., 577; 13 Mar., 732; 1 May, 1232; 8 May, 1294; 15 May, 1377; 29 May, 1498; 12 June, 1620; 19 June, 1686; 4 Sept., 578
Will Corp.
1958: 14 Nov., 1221
Winthrop Laboratories
1959: 13 Feb., 402; 20 Mar., 794; 24 Apr., 1144; 29 May, 1494

CENTRIFUGES

Beckman Instruments, Inc., Spinco Div.
1958: 24 Oct., 927; 28 Nov., 1306
1959: 16 Jan., 114; 20 Mar., 738; 24 Apr., 1042; 15 May, 1306; 22 May, 1394; 17 July, 122; 21 Aug., 410
Custom Scientific Instruments, Inc.
1959: 14 Aug., 394
International Equipment Co.
1958: 24 Oct., 957; 21 Nov., 1303; 5 Dec., 1383; 19 Dec., 1533; 26 Dec., 1596
1959: 9 Jan., 59; 23 Jan., 176; 6 Feb., 295; 20 Feb., 435; 6 Mar., 586; 17 Apr., 993; 15 May, 1321; 12 June, 1631; 26 June, 1703; 10 July, 63; 24 July, 239; 7 Aug., 299; 21 Aug., 415; 4 Sept., 528; 18 Sept., 657
Labline, Inc.
1959: 18 Sept., 744
Lourdes Instrument Corp.
1958: 24 Oct., 963; 14 Nov., 1227; 5 Dec., 1381
1959: 30 Jan., 281; 20 Feb., 501; 6 Mar., 653; 24 Apr., 1147; 15 May, 1375; 26 June, 1749
New York Laboratory Supply Co., Inc.
1959: 20 Feb., 493
Scientific Glass Apparatus Co., Inc.
1959: 23 Jan., 218
Sorvall, Ivan, Inc.
1958: 24 Oct., 933; 14 Nov., 1170; 5 Dec., 1373
1959: 23 Jan., 171; 20 Feb., 439; 20 Mar., 740; 24 Apr., 1183; 15 May, 1310; 19 June, 1637; 17 July, 173; 24 July, 190; 21 Aug., 471; 18 Sept., 666
Will Corp.
1959: 25 Sept., 807

CENTRIFUGE ACCESSORIES

Beckman Instruments, Inc., Spinco Div.
1958: 24 Oct., 927
1959: 16 Jan., 114; 24 Apr., 1042
Corning Glass Works
1959: 10 Apr., 924
Doerr Glass Co.
1959: 20 Mar., 745; 17 Apr., 991; 18 Sept., 667
International Equipment Co.
1959: 9 Jan., 59; 23 Jan., 176; 20 Mar., 743
Research Specialties Co.
1959: 3 Apr., 908
Thomas, Arthur H., Co.
1959: 1 May, 1240

CHEMICALS, BIOLOGICAL

Borden Co., Chemical Div.
1958: 31 Oct., 1093; 21 Nov., 1299
1959: 20 Feb., 512b; 13 Mar., 731; 24 Apr., 1168b; 26 June, 1746
California Corporation for Biochemical Research
1958: 24 Oct., 959; 5 Dec., 1385
Difco Laboratories
1958: 26 Dec., 1631
1959: 20 Feb., 489; 13 Mar., 725; 28 Aug., 516; 25 Sept., 803
H. M. Chemical Co., Ltd.
1959: 15 May, 1368
Mann Research Laboratories, Inc.
1958: 24 Oct., 1029
1959: 20 Feb., 499
Nutritional Biochemicals Corp.
1958: 24 Oct., 1016; 7 Nov., 1155; 21 Nov., 1289; 5 Dec., 1467; 19 Dec., 1586
1959: 2 Jan., 45; 16 Jan., 155; 30 Jan., 278; 13 Feb., 400; 6 Mar., 661; 13 Mar., 728; 20 Mar., 739; 3 Apr., 859; 17 Apr., 987; 1 May, 1187; 15 May, 1307; 29 May, 1451; 12 June, 1571; 26 June, 1699; 10 July, 59; 24 July, 187; 7 Aug., 291; 21 Aug., 411; 4 Sept., 523; 18 Sept., 651

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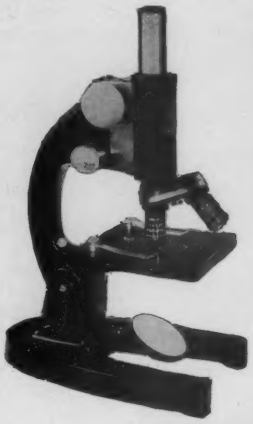

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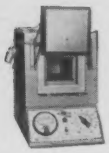

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Pabst Laboratories
1959: 31 July, 283
Schwarz Laboratories, Inc.
1958: 14 Nov., 1217; 5 Dec., 1458; 12 Dec., 1523
1959: 16 Jan., 163; 20 Feb., 507; 20 Mar., 791; 24 Apr., 1161; 15 May, 1383; 29 May, 1495; 19 June, 1691; 10 July, 109; 14 Aug., 403; 11 Sept., 641
Sigma Chemical Co.
1958: 7 Nov., 1162, 1163; 5 Dec., 1443
1959: 2 Jan., 47; 30 Jan., 277; 27 Feb., 573; 27 Mar., 849; 24 Apr., 1155; 22 May, 1441; 17 July, 175; 14 Aug., 392, 393; 11 Sept., 642, 643
Winthrop Laboratories, Special Chemicals Dept.
1958: 24 Oct., 1023; 28 Nov., 1353
1959: 20 Mar., 794; 24 Apr., 1144; 29 May, 1494; 18 Sept., 731

CHEMICALS, GENERAL

Fisher Scientific Co.
1959: 14 Aug., 401
Foote Mineral Co.
1958: 21 Nov., 1240; 12 Dec., 1474
Harshaw Chemical Co., Harshaw Scientific Div.
1959: 9 Jan., 102; 30 Jan., 283; 13 Mar., 726; 3 Apr., 910; 15 May, 1378; 26 June, 1750; 17 July, 179; 7 Aug., 340; 4 Sept., 577; 18 Sept., 746
Macalaster Bicknell Co.
1959: 24 Apr., 1181
Mallinckrodt Chemical Works
1958: 7 Nov., 1102
1959: 24 Apr., 1059; 22 May, 1400
Matheson Co., Inc.
1959: 9 Jan., 104; 6 Mar., 666; 8 May, 1294; 31 July, 276
Pabst Laboratories
1959: 5 June, 1556
Research Specialties Co.
1958: 26 Dec., 1628
Schwarz Laboratories, Inc.
1959: 10 July, 109
Scientific Glass Apparatus Co., Inc.
1959: 15 May, 1309
Weizmann Institute of Science
1958: 24 Oct., 1020

CHEMICALS, TRACER

Matheson Co., Inc.
1959: 19 June, 1686
New England Nuclear Corp.
1959: 15 May, 1372; 29 May, 1503; 12 June, 1626; 26 June, 1752; 3 July, 49; 17 July, 176; 31 July, 287; 14 Aug., 400; 28 Aug., 509; 11 Sept., 635; 18 Sept., 734; 25 Sept., 804
Nuclear-Chicago Corp.
1958: 31 Oct., 1100; 14 Nov., 1232
Radiochemical Centre
1958: 7 Nov., 1151
1959: 2 Jan., 49; 27 Feb., 575; 24 Apr., 1163; 29 May, 1497; 24 July, 231; 18 Sept., 727
Research Specialties Co.
1958: 7 Nov., 1162
1959: 12 June, 1627
Schwarz Laboratories, Inc.
1958: 12 Dec., 1523
1959: 16 Jan., 163; 20 Feb., 507; 20 Mar., 791; 19 June, 1691; 14 Aug., 403
Tracerlab, Inc.
1959: 21 Aug., 468; 25 Sept., 808

CHROMATOGRAPHY EQUIPMENT

Beckman Instruments, Inc.
1958: 24 Oct., 936; 21 Nov., 1234
1959: 20 Feb., 410; 13 Mar., 735; 19 June, 1634; 14 Aug., 407; 28 Aug., 474; 4 Sept., 526, 527
California Laboratory Equipment Co.
1958: 5 Dec., 1460
1959: 23 Jan., 217; 13 Feb., 400; 13 Mar., 728; 27 Mar., 846; 24 Apr., 1142; 15 May, 1373; 5 June, 1563; 10 July, 114; 7 Aug., 344; 4 Sept., 578; 25 Sept., 808
F&M Scientific Corp.
1959: 18 Sept., 726
Hamilton Co., Inc.
1958: 24 Oct., 1014; 5 Dec., 1460
1959: 17 July, 176
Jarrell-Ash Co.
1958: 24 Oct., 944; 21 Nov., 1244; 19 Dec., 1535
Kruger, Harold, Instruments
1959: 28 Aug., 516
Microchemical Specialties Co.
1958: 24 Oct., 1039
New Brunswick Scientific Co.
1959: 13 Feb., 402; 13 Mar., 725; 20 Mar., 789; 10 Apr., 976; 14 Aug., 400
Packard Instrument Co., Inc.
1958: 7 Nov., 1160
1959: 6 Mar., 614
Perkin-Elmer Corp., Instrument Div.
1958: 5 Dec., 1368
1959: 23 Jan., 231; 13 Feb., 407; 10 July, 58
Photovolt Corp.
1958: 24 Oct., 1023; 7 Nov., 1155; 21 Nov., 1289
1959: 8 May, 1292; 19 June, 1685; 24 July, 231; 11 Sept., 643

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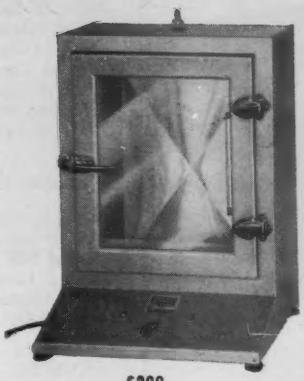

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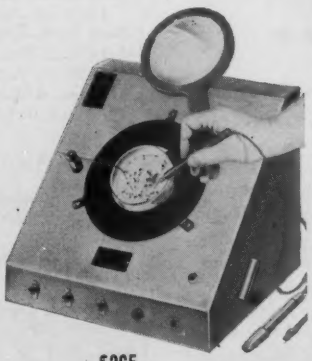

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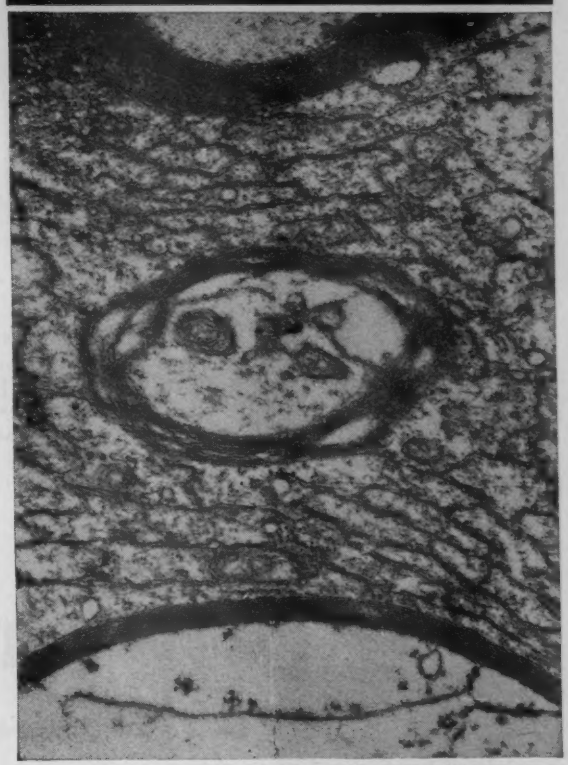

Myelin sheath of Ischiadicus Bufo Vulgaris Formosa. Dr. K. Uchizono.

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M-3024	3"	24"	3400	135	$ 250.00
M-5036	5"	36"	7500	325	$ 650.00
M-8040	8"	40"	14500	520	$1180.00

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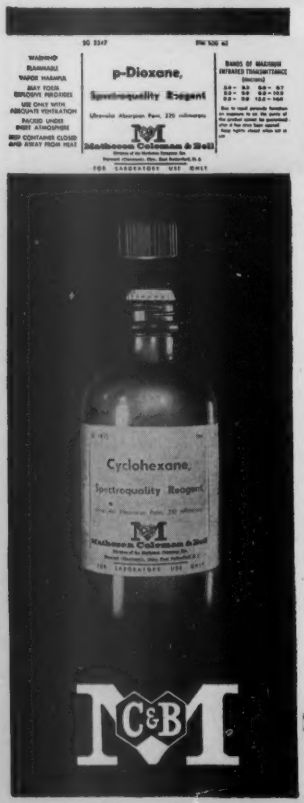

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Research Specialties Co.
1958: 24 Oct., 1012; 19 Dec., 1582; 26 Dec., 1628
1959: 6 Mar., 592; 15 May., 1369; 26 June, 1702; 10 July, 110; 24 July, 230; 7 Aug., 290; 4 Sept., 574
Scientific Glass Apparatus Co., Inc.
1959: 26 June, 1753
Standard Scientific Supply Corp.
1959: 24 Apr., 1148
Technicon Chromatography Corp.
1959: 18 Sept., 733
Ultra-Violet Products, Inc.
1959: 10 July, 118; 18 Sept., 736b

CLEANING EQUIPMENT

Aloe, A. S., Co., Aloe Scientific Div.
1958: 7 Nov., 1161
Barnstead Still & Sterilizer Co., Inc.
1959: 2 Jan., 2; 20 Feb., 527
Branson Ultrasonic Corp.
1958: 24 Oct., 1046

CLEANSERS

Alconox, Inc.
1958: 14 Nov., 1178
1959: 9 Jan., 64; 13 Mar., 684
Greiner, Emil, Co.
1959: 10 Apr., 974
Meinecke & Co., Inc.
1958: 5 Dec., 1446
1959: 20 Feb., 518; 6 Mar., 610; 24 Apr., 1140; 26 June, 1754; 11 Sept., 638

COLORIMETERS AND ACCESSORIES

Bausch & Lomb Optical Co.
1959: 2 Jan., 6; 13 Mar., 688
Instrument Development Laboratories, Inc.
1959: 24 Apr., 1177
Klett Manufacturing Co.
1958: 28 Nov., 1351; 26 Dec., 1631
1959: 23 Jan., 228; 20 Feb., 522; 20 Mar., 788; 17 Apr., 1032; 15 May, 1368; 12 June, 1626; 10 July, 114; 7 Aug., 346; 4 Sept., 578
Kruger, Harold, Instruments
1959: 28 Aug., 516
New York Laboratory Supply Co., Inc.
1958: 5 Dec., 1443
1959: 24 Apr., 1149; 26 June, 1751
Thomas, Arthur H., Co.
1959: 6 Feb., 352

COMBUSTION APPARATUS

Thomas, Arthur H., Co.
1959: 3 Apr., 920; 18 Sept., 741

COMPUTERS

Burroughs Corp., Electro Data Div.
1959: 30 Jan., 234; 20 Feb., 415; 6 Mar., 597; 24 Apr., 1056; 29 May, 1452, 1453
Donner Scientific Co.
1958: 24 Oct., 1045; 7 Nov., 1157; 5 Dec., 1455
1959: 2 Jan., 51; 6 Mar., 671; 22 May, 1436; 10 July, 113
Eldorado Electronics
1958: 14 Nov., 1220
Instrument Development Laboratories, Inc.
1959: 24 Apr., 1177
Philbrick, George A., Researches, Inc.
1959: 20 Mar., 744; 10 Apr., 977

PAGES 1125-1126, ADVERTISEMENT CARD

Royal McBee Corp., Data Processing Div.
1959: 13 Mar., 682; 8 May, 1245; 12 June, 1570; 10 July, 60; 4 Sept., 529
Tracerlab, Inc.
1959: 10 Apr., 929

CONDUCTIVITY APPARATUS

Industrial Instruments, Inc.
1959: 20 Feb., 494; 10 July, 108

CONVERTERS

Eldorado Electronics
1958: 5 Dec., 1452
1959: 23 Jan., 174

DEMINERALIZERS

Barnstead Still & Sterilizer Co., Inc.
1959: 2 Jan., 2; 20 Feb., 527

DENSITOMETERS

Bausch & Lomb Optical Co.
1959: 30 Jan., 242
Photovolt Corp.
1958: 24 Oct., 1023; 7 Nov., 1155; 21 Nov., 1289
1959: 8 May, 1292; 19 June, 1685; 24 July, 231; 11 Sept., 643
Welch, W. M., Manufacturing Co.
1959: 6 Feb., 341; 1 May, 1235

DESALTERS

Research Specialties Co.
1958: 21 Nov., 1298
1959: 24 July, 230

DESICCATORS

Ace Glass, Inc.
1958: 21 Nov., 1290
1959: 15 May, 1376
Phipps & Bird, Inc.
1958: 21 Nov., 1289
1959: 27 Feb., 578

DIFFRACTION GRATINGS

Bausch & Lomb Optical Co.
1959: 13 Feb., 360; 31 July, 244
Farrand Optical Co., Inc.
1958: 21 Nov., 1291; 5 Dec., 1461
1959: 23 Jan., 223

DISTILLATION APPARATUS

New York Laboratory Supply Co., Inc.
1958: 5 Dec., 1443
1959: 24 Apr., 1149; 26 June, 1751

DRAWING SET, MECHANICAL

Edmund Scientific Co.
1958: 28 Nov., 1309; 5 Dec., 1380
1959: 9 Jan., 111; 6 Feb., 299; 6 Mar., 679; 3 Apr., 862

ELECTROMETERS

Applied Physics Corp.
1958: 5 Dec., 1447
1959: 26 June, 1748

ELECTROPHORESIS APPARATUS

Beckman Instruments, Inc., Spinco Div.
1958: 26 Dec., 1594
1959: 23 Jan., 170; 27 Feb., 530; 27

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Mar., 802; 17 Apr., 986; 26 June, 1698; 24 July, 186; 11 Sept., 586; 25 Sept., 754
E-C Apparatus Co.
1958: 24 Oct., 1048
1959: 6 Mar., 654
Karler Laboratories, Inc.
1959: 25 Sept., 809
Kern Co.
1958: 24 Oct., 1040
1959: 20 Feb., 490
Klett Manufacturing Co.
1958: 24 Oct., 1027; 31 Oct., 1096; 7 Nov., 1159; 14 Nov., 1225; 21 Nov., 1286
Laboratory Glass & Instruments Corp.
1958: 24 Oct., 942
1959: 20 Feb., 502
Perkin-Elmer Corp.
1958: 24 Oct., 946; 21 Nov., 1245
Photovolt Corp.
1958: 24 Oct., 1023; 31 Oct., 1093; 7 Nov., 1155; 21 Nov., 1289; 5 Dec., 1449
1959: 6 Feb., 341; 6 Mar., 669; 10 Apr., 980; 8 May, 1292; 15 May, 1385; 19 June, 1685; 26 June, 1745; 24 July, 231; 31 July, 287; 7 Aug., 344; 11 Sept., 643
Research Specialties Co.
1959: 24 July, 230

EVAPORATORS

Instrumentation Associates
1959: 12 June, 1620

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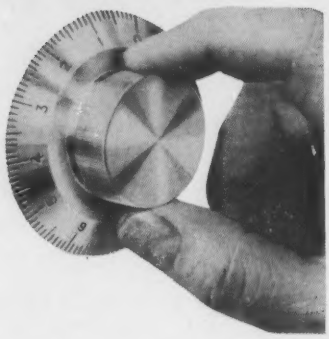

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LABORATORY APPARATUS REAGENTS AND CHEMICALS

Laboratory Glass & Instruments Corp.
1958: 24 Oct., 942; 5 Dec., 1457; 26 Dec., 1629
1959: 20 Feb., 503; 6 Mar., 672; 18 Sept., 729
Phipps & Bird, Inc.
1959: 3 July, 52; 10 July, 111
Scientific Glass Apparatus Co., Inc.
1959: 24 Apr., 1145

FILM

Beseler, Charles, Co., Slide-O-Film Div.
1959: 20 Feb., 414; 17 July, 123

FILM BADGES

Controls for Radiation, Inc.
1958: 19 Dec., 1534
Tracerlab, Inc.
1958: 21 Nov., 1294

FILTERS

Millipore Filter Corp.
1958: 24 Oct., 1042
1959: 20 Feb., 517; 6 Mar., 662; 27 Mar., 851; 24 Apr., 1170; 15 May, 1384; 19 June, 1680
Schleicher, Carl, & Schuell Co.
1959: 24 Apr., 1140; 19 June, 1682

FILTERS, INTERFERENCE

Bausch & Lomb Optical Co.
1959: 30 Jan., 242; 14 Aug., 364
Fish-Schurman Corp.
1959: 20 Feb., 516; 24 Apr., 1143
Photovolt Corp.
1958: 12 Dec., 1520
1959: 13 Mar., 725; 5 June, 1563; 14 Aug., 393

FILTER PAPER

Eaton-Dikeman Co.
1958: 24 Oct., 1044; 14 Nov., 1218; 5 Dec., 1450
1959: 16 Jan., 118; 20 Feb., 494; 20 Mar., 788; 24 Apr., 1166
New York Laboratory Supply Co., Inc.
1959: 20 Feb., 493
Schleicher, Carl, & Schuell Co.
1959: 15 May, 1380; 19 June, 1682; 18 Sept., 720

FLASKS

Ace Glass, Inc.
1959: 6 Feb., 346
Corning Glass Works
1959: 6 Feb., 290; 20 Feb., 496; 26 June, 1705; 10 July, 115; 7 Aug., 293
Doerr Glass Co.
1959: 20 Mar., 745; 17 Apr., 991; 18 Sept., 667
Kimble Glass Co.
1959: 20 Feb., 417; 6 Mar., 603; 24 Apr., 1045; 11 Sept., 589; 18 Sept., 659
Kontes Glass Co.
1959: 28 Aug., 511
Palo Laboratory Supplies, Inc.
1959: 6 Mar., 661
Virtis Co., Inc.
1959: 24 Apr., 1171

FLUOROMETERS

American Instrument Co., Inc.
1958: 12 Dec., 1475

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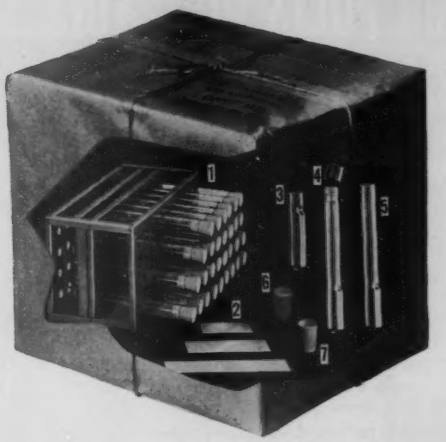

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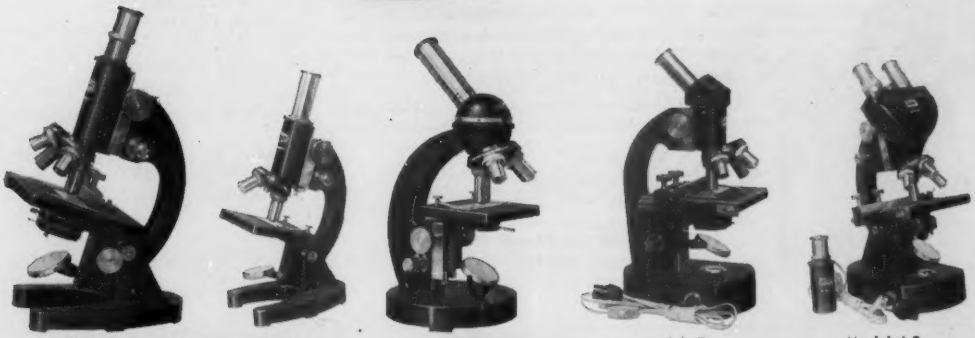

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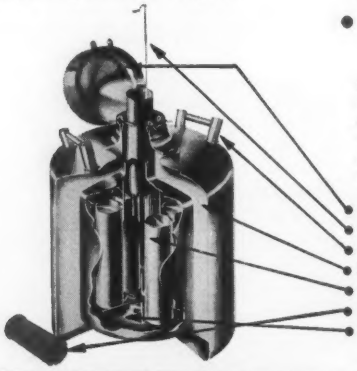
- shrink fitting small metal production parts
- cold storage of aluminum rivets and metallurgical samples
- immediate freezing of animal glands



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Coleman Instruments, Inc.
1959: 20 Feb., 515
Farrand Optical Co., Inc.
1958: 24 Oct., 1033
1959: 20 Feb., 505; 6 Mar., 663; 8 May, 1293; 5 June, 1558
Klett Manufacturing Co.
1958: 12 Dec., 1520
1959: 9 Jan., 106; 6 Feb., 345; 6 Mar., 670; 3 Apr., 912; 1 May, 1235; 29 May, 1497; 26 June, 1752; 24 July, 234; 21 Aug., 468; 18 Sept., 747
Photovolt Corp.
1958: 28 Nov., 1353; 19 Dec., 1583
1959: 16 Jan., 167; 27 Feb., 578; 3 Apr., 915; 1 May, 1235; 12 June, 1623; 17 July, 179; 28 Aug., 514; 18 Sept., 735
Scientific Glass Apparatus Co., Inc.
1958: 21 Nov., 1242

FRACTIONATORS

E-C Apparatus Co.
1958: 24 Oct., 1048
1959: 6 Mar., 669
Gilson Medical Electronics
1958: 24 Oct., 1016
1959: 20 Mar., 789; 22 May, 1437; 14 Aug., 392; 3 July, 55

FRACTION COLLECTORS

Hamilton Co., Inc.
1958: 5 Dec., 1460
1959: 17 July, 176
Packard Instrument Co., Inc.
1958: 7 Nov., 1160
Research Specialties Co.
1959: 30 Jan., 280; 18 Sept., 730

FREEZING EQUIPMENT

American Hospital Supply Corp., Scientific Products Div.
1958: 24 Oct., 960
1959: 20 Feb., 434; 18 Sept., 673
Custom Scientific Instruments, Inc.
1959: 24 Apr., 1156; 14 Aug., 394
Thomas, Arthur H., Co.
1959: 17 July, 128
Virtis Co., Inc.
1958: 24 Oct., 952
1959: 30 Jan., 235

FUME HOODS

Aloe, A. S., Co., Aloe Scientific Div.
1959: 3 Apr., 911
Blickman, S., Inc.
1958: 24 Oct., 1013; 21 Nov., 1246; 19 Dec., 1584
1959: 23 Jan., 222; 20 Feb., 514; 20 Mar., 790
Duralab Equipment Corp.
1959: 15 May, 1383
Kewaunee Manufacturing Co.
1959: 24 Apr., 1152; 21 Aug., 416
Laboratory Furniture Co., Inc.
1958: 24 Oct., 1022

FUNNELS

Ace Glass, Inc.
1959: 6 Mar., 655
Kimble Glass Co.
1959: 16 Jan., 115; 24 Apr., 1045; 11 Sept., 589

FURNACES

Blue M Electric Co.
1959: 18 Sept., 735
Hevi-Dity Duty Electric Co.
1959: 9 Jan., 104; 6 Mar., 666; 8 May, 1296; 10 July, 112
NRC Equipment Corp.
1958: 21 Nov., 1286
Thomas, Arthur H., Co.
1958: 28 Nov., 1360

FURNITURE, LABORATORY

Alberene Stone Corp.
1958: 21 Nov., 1296
Central Scientific Co.
1958: 7 Nov., 1163
1959: 9 Jan., 106; 20 Feb., 505; 21 Aug., 458
Durlab Equipment Corp.
1959: 15 May, 1383; 18 Sept., 745
Fisher Scientific Co.
1958: 24 Oct., 949
1959: 13 Feb., 398
Foringer & Co., Inc.
1958: 5 Dec., 1451
Graphic Systems
1958: 7 Nov., 1156; 5 Dec., 1451
1959: 6 Feb., 342; 5 June, 1556; 18 Sept., 736b
Harshaw Chemical Co.
1959: 9 Jan., 102; 3 Apr., 910; 15 May, 1378; 7 Aug., 340; 18 Sept., 746
Johns-Manville
1958: 24 Oct., 935; 7 Nov., 1105; 21 Nov., 1239; 5 Dec., 1366; 19 Dec., 1531
1959: 13 Feb., 358; 6 Mar., 595; 3 Apr., 865; 24 Apr., 1055; 15 May, 1319; 19 June, 1635; 17 July, 129; 14 Aug., 354; 11 Sept., 593
Laboratory Furniture Co., Inc.
1958: 24 Oct., 1022
Lab-Tek Plastics Co.
1959: 20 Feb., 511; 21 Aug., 466
Luxo Lamp Corp.
1958: 24 Oct., 1015
Macalaster Bicknell Co.
1959: 24 Apr., 1181
Metalab Equipment Co.
1959: 20 Feb., 508; 6 Mar., 664; 10 Apr., 975; 24 Apr., 1157; 26 June, 1755
New Brunswick Scientific Co.
1958: 5 Dec., 1467
1959: 16 Jan., 167; 27 Feb., 573; 3 Apr., 911; 24 Apr., 1176; 17 July, 176
New York Laboratory Supply Co., Inc.
1959: 23 Jan., 227
Standard Scientific Supply Corp.
1959: 20 Feb., 521; 29 May, 1450

GALVANOMETERS

Cambridge Instrument Co., Inc.
1958: 5 Dec., 1441

GAS ANALYZERS

Beckman Instruments, Inc., Spinco Div.
1958: 19 Dec., 1530
Harvard Apparatus Co., Inc.
1958: 24 Oct., 1013
Industrial Instruments Engineering Corp.
1958: 24 Oct., 1043

GAS CONTAINERS

Union Carbide Corp., Linde Co. Div.
1959: 24 Apr., 1178; 21 Aug., 460

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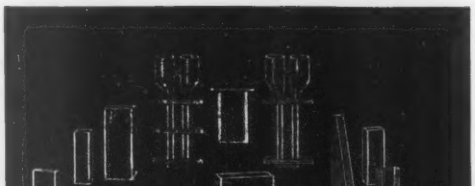

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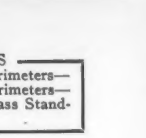

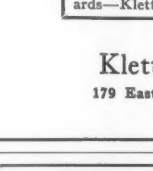

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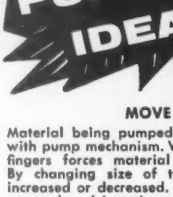

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GAS METERS

Phipps & Bird, Inc.
1958: 14 Nov., 1231

GAUGES

Ace Glass, Inc.
1958: 24 Oct., 1020

GAUSSMETERS

Rawson Electrical Instrument Co.
1958: 24 Oct., 1020

GENERATORS

American Electronic Laboratories, Inc.
1959: 25 Sept., 804
Avco Corp.
1959: 11 Sept., 596
Donner Scientific Co.
1959: 20 Feb., 509; 3 Apr., 907
Philbrick, George A., Researches, Inc.
1959: 20 Feb., 425
Radio Corporation of America
1959: 21 Aug., 457
Raytheon Manufacturing Co.
1959: 26 June, 1754; 28 Aug., 513; 25 Sept., 805
Science Materials Center
1959: 20 Feb., 413
Texas Nuclear Corp.
1959: 6 Mar., 651

GLASS ETCHING

Mann, David W., Inc.
1959: 27 Mar., 846; 24 Apr., 1143

GLASSWARE AND ACCESSORIES

Ace Glass, Inc.
1958: 19 Dec., 1580
1959: 16 Jan., 116; 6 Feb., 346; 6 Mar., 655; 24 Apr., 1174
Bellco Glass, Inc.
1958: 31 Oct., 1093; 28 Nov., 1356; 26 Dec., 1631
1959: 30 Jan., 283; 20 Feb., 510; 3 Apr., 915; 24 Apr., 1142; 29 May, 1494; 31 July, 280; 28 Aug., 508
Corning Glass Works
1958: 24 Oct., 965; 5 Dec., 1378; 19 Dec., 1532
1959: 6 Feb., 290; 20 Feb., 496; 13 Mar., 727; 10 Apr., 924; 15 May, 1382; 5 June, 1515; 26 June, 1705; 10 July, 115; 7 Aug., 291; 11 Sept., 640
Doerr Glass Co.
1959: 30 Jan., 239; 20 Feb., 423; 20 Mar., 745; 17 Apr., 991; 18 Sept., 667
Fischer & Porter Co.
1958: 24 Oct., 953
Greiner, Emil, Co.
1959: 23 Jan., 220
Harshaw Chemical Co.
1959: 9 Jan., 102; 3 Apr., 910; 15 May, 1378; 7 Aug., 340; 18 Sept., 746
Kimble Glass Co.
1959: 16 Jan., 115; 20 Feb., 417; 6 Mar., 603; 24 Apr., 1045; 11 Sept., 589; 18 Sept., 659
Klett Manufacturing Co.
1958: 24 Oct., 1027; 31 Oct., 1096; 7 Nov., 1159; 14 Nov., 1225; 21 Nov., 1286; 28 Nov., 1351; 5 Dec., 1445; 12 Dec., 1520; 19 Dec., 1586; 26 Dec., 1631
1959: 2 Jan., 47; 9 Jan., 106; 16 Jan., 158; 23 Jan., 228; 30 Jan., 278; 6 Feb., 345; 13 Feb., 400; 20 Feb., 522; 27 Feb., 574; 6 Mar., 670; 13 Mar., 728; 20 Mar., 788; 27 Mar., 846; 3 Apr., 912; 10 Apr., 976; 17 Apr., 1032; 24 Apr., 1159; 1 May, 1235; 8 May, 1298; 15 May, 1368; 22 May, 1442; 29 May, 1497; 5 June, 1558; 12 June, 1626; 19 June, 1685; 26 June, 1752; 3 July, 55; 10 July, 114; 17 July, 175; 24 July, 234; 31 July, 279; 7 Aug., 346; 14 Aug., 400; 21 Aug., 468; 28 Aug., 508; 4 Sept., 579; 11 Sept., 643; 18 Sept., 747; 25 Sept., 804
Kontes Glass Co.
1959: 20 Mar., 746; 17 Apr., 992; 22 May, 1440; 29 May, 1499; 12 June, 1580; 19 June, 1690; 26 June, 1756; 10 July, 66; 24 July, 188; 7 Aug., 298; 14 Aug., 395; 28 Aug., 511; 11 Sept., 637; 25 Sept., 810
Palo Laboratory Supplies, Inc.
1959: 6 Mar., 661
Scientific Glass Apparatus Co., Inc.
1959: 15 May, 1309
Thomas, Arthur H., Co.
1959: 3 Apr., 920
Welch, W. M., Manufacturing Co.
1958: 5 Dec., 1445

GLOBE, CELESTIAL

Lafayette Radio Co.
1959: 18 Sept., 736

GLOVES, DRY BOX

Charleston Rubber Co.
1959: 24 Apr., 1063; 1 May, 1233

GYROSCOPES

Central Scientific Co.
1959: 12 June, 1622; 24 July, 231

HEATERS

Central Scientific Co.
1958: 26 Dec., 1631
1959: 20 Mar., 793
Hevi-Duty Electric Co.
1959: 6 Mar., 666
Research Specialties Co.
1959: 20 Feb., 498; 29 May, 1496
Standard Scientific Supply Corp.
1959: 24 July, 232

HOMOGENIZERS

Instrumentation Associates
1959: 18 Sept., 740
Tri-R Instruments
1958: 24 Oct., 1011
1959: 20 Feb., 497
Virtis Co., Inc.
1958: 24 Oct., 952
1959: 30 Jan., 235

INCUBATORS

American Instrument Co.
1959: 24 Apr., 1153
National Appliance Co.
1959: 18 Sept., 724
New Brunswick Scientific Co.
1959: 2 Jan., 47; 23 Jan., 217
Standard Scientific Supply Corp.
1958: 14 Nov., 1222

INTERFEROMETERS

Central Scientific Co.
1959: 12 June, 1623; 17 July, 179

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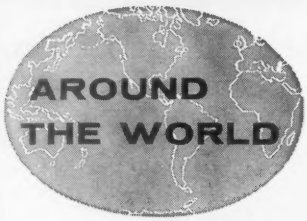

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Kimble Glass Co.
1959: 16 Jan., 115
Thomas, Arthur H., Co.
1958: 5 Dec., 1362

KYMOGRAPHS AND ACCESSORIES

Harvard Apparatus Co., Inc.
1959: 8 May, 1293
Phipps & Bird, Inc.
1959: 9 Jan., 103; 23 Jan., 217; 27 Mar., 845; 3 Apr., 915; 22 May, 1437; 29 May, 1503; 18 Sept., 743

LABELS, TIME

Professional Tape Co., Inc.
1958: 14 Nov., 1224
1959: 16 Jan., 160; 13 Feb., 403; 13 Mar., 724; 27 Mar., 846; 10 Apr., 972; 24 Apr., 1144; 8 May, 1292; 22 May, 1443; 12 June, 1626; 4 Sept., 575; 18 Sept., 731

LABORATORY CLAMPS

New York Laboratory Supply Co., Inc.
1958: 24 Oct., 1019
1959: 23 Jan., 227
Standard Scientific Supply Corp.
1959: 26 June, 1707

LABORATORY EQUIPMENT

Brinkmann Instruments, Inc.
1958: 24 Oct., 938
Fisher Scientific Co.
1958: 14 Nov., 1226; 12 Dec., 1518
Harshaw Chemical Co., Harshaw Scientific Div.
1959: 20 Feb., 492; 19 June, 1689
Kewaunee Manufacturing Co.
1958: 28 Nov., 1355
Labline, Inc.
1959: 15 May, 1324
Macalaster Bicknell Co.
1959: 24 Apr., 1181
Metro Industries
1958: 24 Oct., 1039
Scientific Glass Apparatus Co., Inc.
1959: 15 May, 1309
Standard Scientific Supply Corp.
1958: 24 Oct., 1038
Will Corp.
1958: 24 Oct., 1034; 14 Nov., 1221

LABORATORY EQUIPMENT, NUCLEONIC

Anton Electronic Laboratories, Inc.
1959: 9 Jan., 105
Applied Physics Corp.
1959: 26 June, 1748
Atomic Energy of Canada Limited, Commercial Products Div.
1959: 14 Aug., 360
Baird-Atomic, Inc.
1958: 24 Oct., 1028; 5 Dec., 1440
Budd Co., Nuclear Systems Div.
1958: 24 Oct., 954
1959: 20 Feb., 436; 6 Mar., 606; 24 Apr., 1052; 26 June, 1706; 7 Aug., 294
Curtiss-Wright Corp., Princeton Div.
1959: 7 Aug., 347
Hamilton Co.
1958: 14 Nov., 1225
High Voltage Engineering Corp.
1958: 14 Nov., 1182; 5 Dec., 1389
Nuclear-Chicago Corp.
1958: 31 Oct., 1100; 14 Nov., 1232; 12 Dec., 1528
1959: 23 Jan., 231; 20 Feb., 528; 20 Mar., 800; 17 Apr., 1040; 15 May, 1392; 26 June, 1760; 24 July, 240; 21 Aug., 472; 18 Sept., 752
Nuclear Electronics Corp.
1959: 27 Feb., 576; 13 Mar., 731; 20 Mar., 790; 27 Mar., 852; 3 Apr., 864
Nuclear Measurements Corp.
1958: 21 Nov., 1292
1959: 18 Sept., 740
Nuclear Science and Engineering Corp.
1959: 20 Feb., 495; 6 Mar., 676; 3 Apr., 906; 24 Apr., 1167; 15 May, 1387; 5 June, 1557; 14 Aug., 397; 18 Sept., 721
Nucleonic Corporation of America
1959: 3 July, 5
Packard Instrument Co., Inc.
1958: 31 Oct., 1054; 21 Nov., 1248; 19 Dec., 1536; 26 Dec., 1636
Picker X-Ray Corp.
1959: 12 June, 1575
Technical Measurement Corp.
1958: 5 Dec., 1390
Victoreen Instrument Co.
1959: 21 Aug., 461

LABORATORY EQUIPMENT, PLASTIC

Ace Glass, Inc.
1958: 21 Nov., 1290
1959: 15 May, 1376
Bel-Art Products
1959: 20 Feb., 497
Falcon Plastics
1959: 6 Mar., 601; 17 Apr., 994; 15 May, 1391; 5 June, 1509; 25 Sept., 759
Greiner, Emil, Co.
1959: 15 May, 1374
Lab-Tek Plastics Co.
1959: 10 Apr., 978; 19 June, 1684
Maryland Plastics, Inc.
1959: 3 Apr., 864
Nalge Co., Inc.
1958: 24 Oct., 1036
Thomas, Arthur H., Co.
1959: 7 Aug., 352

LABORATORY-JACK

Central Scientific Co.
1958: 21 Nov., 1299
1959: 27 Mar., 845; 18 Sept., 735

LABORATORY PRESS

Lee Engineering Co.
1958: 7 Nov., 1152; 5 Dec., 1451

LAMPS

American Instrument Co., Inc.
1958: 12 Dec., 1475
Aristo Grid Lamp Products, Inc.
1958: 7 Nov., 1156
Bausch & Lomb Optical Co.
1959: 10 Apr., 936
Ednalite Optical Co.
1959: 6 Mar., 657
Luxo Lamp Corp.
1958: 24 Oct., 1015
Ultra-Violet Products, Inc.
1958: 24 Oct., 1024; 5 Dec., 1450
1959: 20 Feb., 490; 28 Aug., 510

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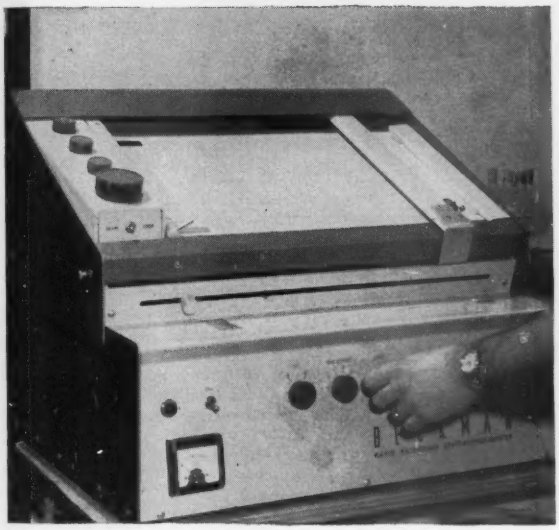

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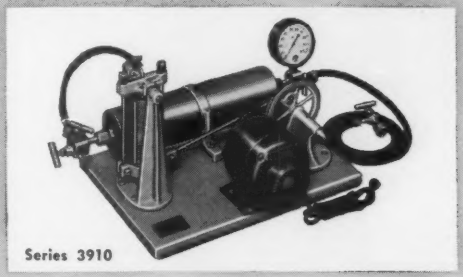

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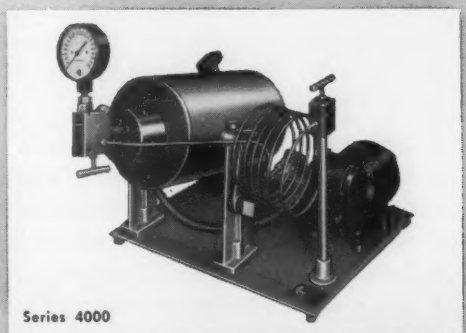

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Lee Engineering Co.
1958: 21 Nov., 1290; 19 Dec., 1580
1959: 9 Jan., 108

MACROSCOPES

Bausch & Lomb Optical Co.
1958: 5 Dec., 1392
1959: 27 Mar., 806; 8 May, 1248; 3 July, 8

MAGNETS

Edmund Scientific Co.
1959: 1 May, 1188; 10 July, 62

Varian Associates, Instrument Div.
1959: 14 Aug., 356, 357; 18 Sept., 654, 655

MACHINE TOOLS, PRECISION

American-Edelstaal Unimat Div.
1959: 6 Mar., 655; 24 Apr., 1164; 18 Sept., 741

MANOMETERS

Gilson Medical Electronics
1959: 17 Apr., 988
Will Corp., Bronwill Scientific Div.
1959: 27 Feb., 579

MEASURING INSTRUMENTS, PRECISION

B & H Instrument Co., Inc.
1959: 10 July, 67; 18 Sept., 662
Mann, David W., Inc.
1959: 27 Mar., 846; 24 Apr., 1143

MELTING-POINT APPARATUS

Fisher Scientific Co.
1959: 6 Mar., 660
Nalge Co., Inc.
1959: 20 Feb., 516
Thomas, Arthur H., Co.
1959: 6 Mar., 680; 4 Sept., 584

MICROANALYSIS EQUIPMENT

Ace Glass, Inc.
1959: 24 Apr., 1174
Ainsworth, Wm., & Sons, Inc.
1958: 21 Nov., 1295
Aloe, A. S., Co., Aloe Scientific Div.
1959: 6 Feb., 345; 6 Mar., 673
Biological Institute
1958: 21 Nov., 1290
Brinkmann Instruments, Inc.
1959: 24 Apr., 1159
Corning Glass Works
1959: 5 June, 1515
Greiner, Emil, Co.
1959: 9 Jan., 108; 20 Feb., 490; 13 Mar., 731
Hamilton Co.
1958: 24 Oct., 1014
1959: 20 Feb., 505
Kontes Glass Co.
1959: 27 Mar., 848; 17 Apr., 992; 24 Apr., 1172; 8 May, 1295; 29 May, 1499; 12 June, 1580; 24 July, 188
Lab-Tek Plastics Co.
1959: 10 Apr., 978
Millipore Filter Corp.
1958: 24 Oct., 1042
Metro Industries
1958: 24 Oct., 1039
Nalge Co., Inc.
1958: 24 Oct., 1036
Norton Products
1958: 21 Nov., 1241; 5 Dec., 1369
Scientific Industries, Inc.
1958: 24 Oct., 1024
1959: 6 Mar., 652
Standard Scientific Supply Corp.
1959: 16 Jan., 162; 18 Sept., 722
Stoelting, C. H., Co.
1958: 21 Nov., 1287
1959: 16 Jan., 158; 20 Feb., 499; 20 Mar., 794; 24 Apr., 1171; 29 May, 1500

MICROBIOLOGICAL EQUIPMENT

American Sterilizer Co.
1959: 6 Mar., 605
Beckman Instruments, Inc., Spinco
1958: 21 Nov., 1234
1959: 20 Feb., 410
Bellco Glass, Inc.
1958: 31 Oct., 1093; 28 Nov., 1356; 26 Dec., 1631
1959: 30 Jan., 283; 3 Apr., 915; 24 Apr., 1142; 29 May, 1494; 26 June, 1752; 31 July, 280; 28 Aug., 508; 25 Sept., 812
Delmar Scientific Laboratories
1958: 24 Oct., 1030
Falcon Plastics
1959: 6 Mar., 601; 15 May, 1391; 5 June, 1509

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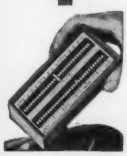

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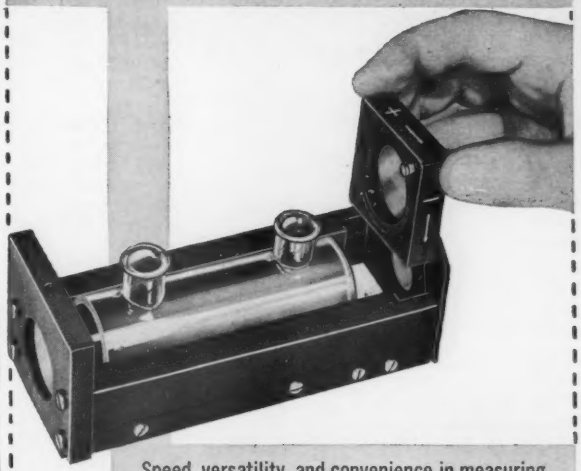

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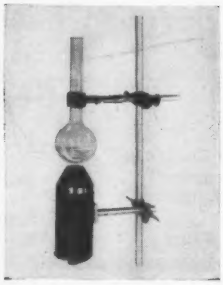

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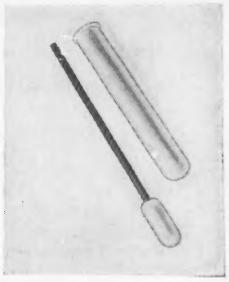

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1959: 15 May, 1368
Kewaunee Manufacturing Co.
1958: 28 Nov., 1355
Kontes Glass Co.
1959: 22 May, 1440; 28 Aug., 511
National Appliance Co.
1959: 23 Jan., 224
New Brunswick Scientific Co.
1958: 24 Oct., 1016
1959: 9 Jan., 106; 20 Mar., 789
New Brunswick Scientific Co., Inc.
1959: 3 July, 49; 11 Sept., 642
Phoenix Precision Instrument Co.
1959: 20 Feb., 420
Thomas, Arthur H., Co.
1959: 1 May, 1240
Virtis Co., Inc.
1958: 24 Oct., 952
1959: 30 Jan., 235

MICROBIOLOGICAL MEDIA

Clinton Laboratories
1958: 24 Oct., 1019; 5 Dec., 1464
1959: 20 Feb., 516
Colorado Serum Co.
1958: 24 Oct., 1023; 14 Nov., 1228; 5 Dec., 1449
1959: 20 Feb., 522; 24 Apr., 1151; 15 May, 1385; 12 June, 1625
Connaught Medical Research Laboratories
1959: 3 July, 45
Difco Laboratories
1958: 28 Nov., 1349; 26 Dec., 1631
1959: 20 Feb., 489; 13 Mar., 725; 24 Apr., 1171; 28 Aug., 516; 25 Sept., 803
Greiner, Emil, Co.
1959: 15 May, 1374
Hyland Laboratories
1958: 24 Oct., 1037; 5 Dec., 1463
1959: 23 Jan., 219; 20 Feb., 513; 6 Mar., 669; 22 May, 1443; 24 July, 235; 18 Sept., 723
Matheson Co., Inc.
1959: 31 July, 276
Worthington Biochemical Corp.
1959: 7 Aug., 346

MICROCARDS AND ACCESSORIES

American Optical Co.
1958: 19 Dec., 1592
Microcard Corp.
1958: 7 Nov., 1151

MICROMANIPULATORS

Aloe, A. S., Co., Aloe Scientific Div.
1959: 6 Feb., 345; 6 Mar., 673
Brinkmann Instruments, Inc.
1959: 24 Apr., 1159
Stoelting, C. H., Co.
1959: 20 Mar., 794; 24 Apr., 1171; 29 May, 1500

MICROSCOPES

Aloe, A. S., Co., Aloe Scientific Div.
1959: 15 May, 1385; 5 June, 1555
American Optical Co.
1958: 21 Nov., 1304
1959: 2 Jan., 56; 24 Apr., 1184; 22 May, 1448; 5 June, 1568; 14 Aug., 408; 28 Aug., 520; 11 Sept., 648
Bausch & Lomb Optical Co.
1958: 24 Oct., 968; 21 Nov., 1250; 19 Dec., 1538
1959: 16 Jan., 122; 27 Feb., 536; 24 Apr., 1074; 17 July, 132
Brinkmann Instruments, Inc.
1958: 21 Nov., 1299
Elgeet Optical Co., Inc.
1959: 18 Sept., 669
General Electric Co.
1958: 24 Oct., 1018; 5 Dec., 1444
Graf-Apsco Co.
1958: 31 Oct., 1093
1959: 23 Jan., 219; 6 Feb., 341; 27 Feb., 573; 10 Apr., 976; 8 May, 1298; 25 Sept., 804
Hacker, William J., & Co., Inc.
1958: 24 Oct., 962
1959: 6 Mar., 659; 10 Apr., 979; 5 June, 1563; 19 June, 1681
Leitz, E., Inc.
1958: 7 Nov., 1104; 21 Nov., 1247; 5 Dec., 1371
1959: 20 Feb., 433; 6 Mar., 590; 20 Mar., 741; 10 Apr., 930; 8 May, 1244; 22 May, 1399; 5 June, 1510; 17 July, 183; 28 Aug., 519; 18 Sept., 674
United Scientific Co.
1958: 24 Oct., 1051; 14 Nov., 1219; 21 Nov., 1243
1959: 9 Jan., 107; 23 Jan., 222; 30 Jan., 237; 27 Feb., 577; 27 Mar., 852; 17 Apr., 1030; 24 Apr., 1169; 12 June, 1620; 4 Sept., 578
Wild Heerbrugg Instruments, Inc.
1958: 24 Oct., 1021; 14 Nov., 1178; 21 Nov., 1288; 5 Dec., 1454; 19 Dec., 1584
1959: 2 Jan., 50; 16 Jan., 164; 13 Mar., 729; 27 Mar., 847; 24 Apr., 1160; 8 May, 1295; 5 June, 1514; 19 June, 1690; 11 Sept., 637; 25 Sept., 810
Will Corp.
1959: 20 Feb., 519
Zeiss, Carl, Inc.
1958: 7 Nov., 1106; 21 Nov., 1238
1959: 16 Jan., 119; 15 May, 1325; 5 June, 1506; 10 July, 61; 4 Sept., 525; 11 Sept., 595

MICROSCOPES, ELECTRON

Bendix Aviation Corp., Cincinnati Div.
1959: 15 May, 1379
Erb & Gray Scientific, Inc.
1958: 21 Nov., 1287
1959: 16 Jan., 153; 23 Jan., 227; 24 Apr., 1151; 18 Sept., 739
Philips Electronics, Inc.
1959: 4 Sept., 531; 18 Sept., 658
Radio Corporation of America
1959: 20 Feb., 437; 19 June, 1639
Siemens, New York, Inc.
1959: 15 May, 1320; 18 Sept., 751

MICROSCOPES, PHASE

American Optical Co.
1958: 5 Dec., 1472
1959: 3 July, 56
Hacker, William J., & Co., Inc.
1958: 24 Oct., 962
United Scientific Co.
1958: 19 Dec., 1587
1959: 20 Feb., 421; 6 Mar., 665; 15 May, 1377; 5 June, 1513; 17 July, 127; 14 Aug., 361
Wild Heerbrugg Instruments, Inc.
1959: 31 July, 283; 28 Aug., 511

MICROSCOPES, STEREO

American Optical Co.
1959: 16 Jan., 168; 27 Feb., 584; 13 Mar., 736; 19 June, 1696; 25 Sept., 816
Bausch & Lomb Optical Co.
1958: 5 Dec., 1392
1959: 27 Mar., 806; 22 May, 1402; 19 June, 1642; 28 Aug., 476; 25 Sept., 762
Edmund Scientific Co.
1959: 9 Jan., 111; 10 July, 62
United Scientific Co.
1958: 5 Dec., 1365; 12 Dec., 1524
1959: 6 Mar., 665; 29 May, 1498; 5 June, 1513; 26 June, 1746; 17 July, 127; 14 Aug., 361; 11 Sept., 640; 18 Sept., 737; 25 Sept., 803
Wild Heerbrugg Instruments, Inc.
1959: 30 Jan., 238; 13 Feb., 399; 27 Feb., 534; 10 Apr., 977; 22 May, 1398; 3 July, 4; 14 Aug., 398
Will Corp.
1959: 26 June, 1747
Zeiss, Carl, Inc.
1958: 5 Dec., 1379

MICROSCOPES, STUDENT

Bausch & Lomb Optical Co.
1959: 3 July, 8; 28 Aug., 476
Edmund Scientific Co.
1958: 14 Nov., 1175; 28 Nov., 1309; 5 Dec., 1380
1959: 6 Feb., 299; 6 Mar., 679; 3 Apr., 862; 5 June, 1508; 7 Aug., 351
Elgeet Optical Co., Inc.
1959: 18 Sept., 669
Graf-Apsco Co.
1958: 24 Oct., 1027; 7 Nov., 1163; 14 Nov., 1223; 5 Dec., 1463
1959: 16 Jan., 158; 20 Feb., 513; 6 Mar., 670; 24 Apr., 1177; 15 May, 1372; 18 Sept., 723
Leitz, E., Inc.
1959: 10 Apr., 930; 24 Apr., 1044; 14 Aug., 358
United Scientific Co.
1958: 24 Oct., 1051; 5 Dec., 1365
1959: 30 Jan., 237; 6 Mar., 665; 24 Apr., 1169; 18 Sept., 737

MICROSCOPE ACCESSORIES

Aloe, A. S., Co., Aloe Scientific Div.
1959: 15 May, 1385; 5 June, 1555
American Optical Co.
1959: 16 Jan., 168; 10 Apr., 984; 31 July, 288; 14 Aug., 408; 11 Sept., 648; 25 Sept., 816
Bausch & Lomb Optical Co.
1958: 7 Nov., 1110
1959: 24 Apr., 1074
Brinkmann Instruments, Inc.
1959: 10 Apr., 973
Custom Scientific Instruments, Inc.
1959: 16 Jan., 156; 14 Aug., 394
Hacker, William J., & Co., Inc.
1959: 5 June, 1563; 19 June, 1681
Leitz, E., Inc.
1958: 21 Nov., 1247
1959: 22 May, 1399; 28 Aug., 519
Monroe Microscope Service
1959: 17 July, 175
Rosenthal, Paul
1959: 15 May, 1376b
United Scientific Co.
1958: 19 Dec., 1587
1959: 24 Apr., 1169; 15 May, 1377; 5 June, 1513; 17 July, 127; 14 Aug., 361; 18 Sept., 737
Wild Heerbrugg Instruments, Inc.
1959: 28 Aug., 511; 11 Sept., 637
Zeiss, Carl, Inc.
1959: 4 Sept., 525

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Calcium Fluoride	Quartz

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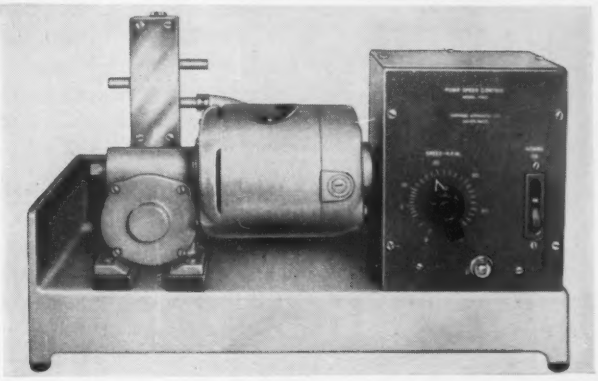

SPECIFICATIONS

- Volume: adjustable up to 750 cc.
- Rates: 5-50 strokes/min. continuously adjustable
- Motor: 1/15 H.P., 115 volt operation
- Control Box: Variac and rectifier combination with calibrated speed dial
- Valves: flutter type of neoprene-impregnated nylon
- Pump: nickeled brass with neoprene piston rings

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MICROTOMES AND ACCESSORIES

Aloe, A. S., Co., Aloe Scientific Div.
1959: 3 July, 45
American Optical Co.
1959: 13 Feb., 408; 8 May, 1304; 17 July, 184
Brinkmann Instruments, Inc.
1959: 14 Aug., 359
Brunswick-Balke-Collender Co.
1959: 4 Sept., 579
Hacker, William J., & Co., Inc.
1958: 24 Oct., 962
1959: 20 Feb., 430
International Equipment Co.
1959: 3 Apr., 868; 1 May, 1191
Leitz, E., Inc.
1959: 11 Sept., 588
Research Specialties Co.
1959: 24 Apr., 1154
Sorvall, Ivan, Inc.
1958: 24 Oct., 933; 14 Nov., 1170; 5 Dec., 1373
Thomas, Arthur H., Co.
1959: 10 July, 120

MICRO-WAVE APPARATUS

Central Scientific Co.
1958: 12 Dec., 1520
1959: 6 Mar., 670; 15 May, 1368; 10 July, 114; 14 Aug., 393

This is the

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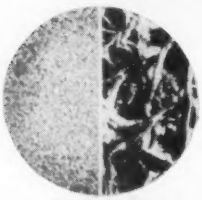
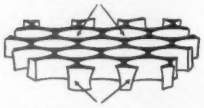
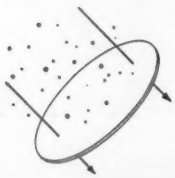


Left: Millipore Filter
Right: "Dense" analytical filter paper
(Photomicrograph at 100X)

Pore Volume 80%



Solid (Matrix) Volume 20%



50 MILLION CAPILLARY PORES PER SQ. CM. OF SURFACE AREA

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PORES ARE 80% OF TOTAL FILTER VOLUME

Because of the high ratio of pores to solid matrix, the flow rate of liquids or gases through the Millipore filter is extraordinarily high for such a minute pore size.

ABSOLUTE SURFACE RETENTION OF ALL PARTICLES LARGER THAN PORE SIZE

Particles screened from liquids or gases lie directly on the surface of the Millipore filter — in a single plane — where they may be readily examined or tested. Fluids are cleaned with 100% cut-off at specific pore size.

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Pore size is precisely controlled. For instance, in the HA grade, the variation of screen opening is ±4% at a nominal pore size of 0.45 micron.

Type Code	Pore Size (microns)	Pore Dia. Variation	Rate of Flow* Water	Air
VF	10 mμ	±2 mμ	1.1	100
VM	50 mμ	±3 mμ	2.7	200
VC	100 mμ	±8 mμ	3.6	600
PH	0.30μ	±.02μ	40	4200
HA	0.45μ	±.02μ	80	9600
DA	0.65μ	±.03μ	175	28000
AA	0.80μ	±.05μ	220	33000
RA	1.2μ	±.3μ	300	38000
SS	3.0μ	±.9μ	400	45000
SM	5.0μ	±1.2μ	560	70000

*Mean Flow rates in cc/min/cm² filter area @ 25°C and 70 cm Hg △ p

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MIXERS

Eastern Industries, Inc.
1959: 24 Apr., 1181
Laboratory Glass & Instruments Corp.
1959: 18 Sept., 729
Sorvall, Ivan, Inc.
1958: 14 Nov., 1170

MOLECULAR MODEL SET

Edmund Scientific Co.
1959: 11 Sept., 592
Scientific Glass Apparatus Co., Inc.
1959: 23 Jan., 218
Standard Scientific Supply Corp.
1958: 5 Dec., 1448
Will Corp.
1958: 19 Dec., 1581
1959: 14 Aug., 399

MONITORS, AIR

Anton Electronic Laboratories, Inc.
1958: 24 Oct., 950
1959: 6 Mar., 600
Atomic Accessories, Inc.
1959: 20 Feb., 518
Nuclear Measurements Corp.
1959: 15 May, 1382

MONOCHROMATORS

Bausch & Lomb Optical Co.
1959: 5 June, 1518
Beckman Instruments, Inc., Scientific and Process Instruments Div.
1958: 5 Dec., 1370
1959: 6 Feb., 297; 10 July, 65
Farrand Optical Co., Inc.
1958: 21 Nov., 1291; 5 Dec., 1461
1959: 23 Jan., 223
Photovolt Corp.
1958: 14 Nov., 1225
1959: 2 Jan., 45; 13 Feb., 400; 27 Mar., 845; 24 Apr., 1151; 22 May, 1437; 3 July, 51; 4 Sept., 575

NEPHELOMETERS

Coleman Instruments, Inc.
1959: 6 Mar., 675
Klett Manufacturing Co.
1958: 5 Dec., 1445
1959: 2 Jan., 47; 30 Jan., 278; 27 Feb., 574; 27 Mar., 846; 24 Apr., 1159; 22 May, 1442; 19 June, 1685; 17 July, 175; 14 Aug., 400; 11 Sept., 643
Scientific Glass Apparatus Co., Inc.
1958: 21 Nov., 1242

OPTICAL CRYSTALS

Harshaw Chemical Co.
1958: 7 Nov., 1161
1959: 30 Jan., 283; 13 Mar., 726; 26 June, 1750; 17 July, 179; 4 Sept., 577
Isomet Corp.
1959: 27 Feb., 574; 24 Apr., 1159; 12 June, 1622

OSCILLATORS, SONIC

Raytheon Manufacturing Co.
1958: 24 Oct., 939; 21 Nov., 1237
1959: 20 Feb., 438; 10 Apr., 925; 24 Apr., 1168a; 17 July, 181; 18 Sept., 736a

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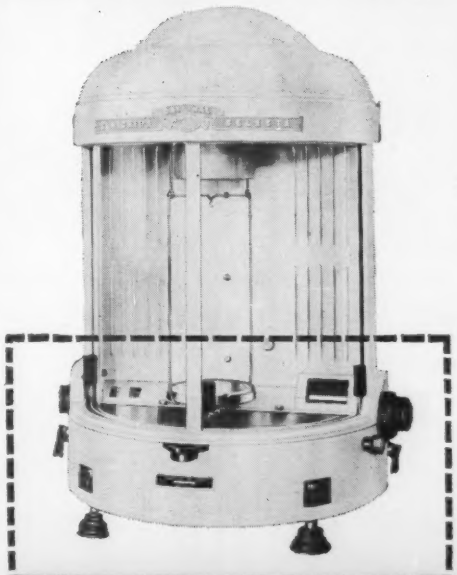

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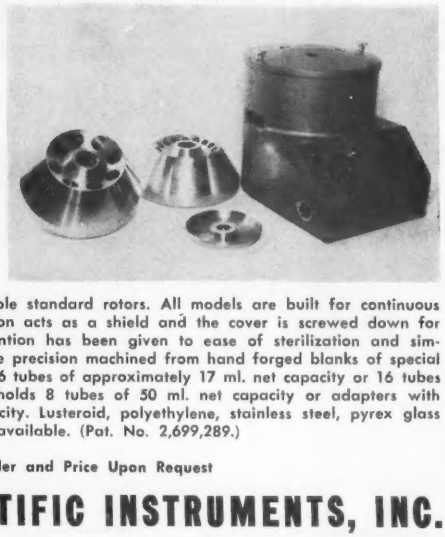

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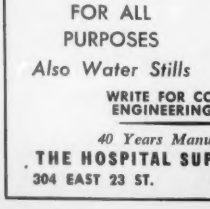

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OSMOMETER

Rosemount Engineering Co., Medical Instruments Dept.
1959: 18 Sept., 743

OVENS

Hevi-Duty Electric Co.
1959: 18 Sept., 745
New Brunswick Scientific Co.
1958: 24 Oct., 1016
1959: 13 Feb., 402; 13 Mar., 725; 20 Mar., 789; 10 Apr., 976; 14 Aug., 400
New York Laboratory Supply Co., Inc.
1959: 20 Feb., 493
Precision Scientific Co.
1959: 15 May, 1386
Research Specialties Co.
1959: 26 June, 1702; 7 Aug., 290
Scientific Glass Apparatus Co., Inc.
1958: 24 Oct., 1026
Standard Scientific Supply Corp.
1959: 8 May, 1296

PERIODIC TABLE OF THE ELEMENTS

Central Scientific Co.
1959: 28 Aug., 514; 11 Sept., 635
Welch, W. M., Manufacturing Co.
1959: 5 June, 1555; 7 Aug., 341

PETRI DISHES

Falcon Plastics
1959: 6 Mar., 601; 17 Apr., 994; 15 May, 1391; 5 June, 1509
Lab-Tek Plastics Co.
1959: 19 June, 1684

*p*H INDICATORS

Analytical Measurements, Inc.
1958: 24 Oct., 1048
Beckman Instruments, Inc., Scientific and Process Instruments Div.
1958: 14 Nov., 1176, 1177
1959: 9 Jan., 62, 63; 8 May, 1303; 24 July, 189
Brinkmann Instruments, Inc.
1959: 14 Aug., 359
Cambridge Instrument Co., Inc.
1959: 20 Feb., 510
Coleman Instruments, Inc.
1958: 24 Oct., 1031
1959: 24 Apr., 1168; 15 May, 1381; 19 June, 1683
Welwyn International, Inc.
1959: 24 Apr., 1062; 12 June, 1572
Will Corp.
1959: 20 Feb., 519

PHOTOMETERS

Advanced Instruments, Inc.
1958: 24 Oct., 1032
American Instrument Co., Inc.
1959: 8 May, 1297
Baird-Atomic, Inc.
1959: 16 Jan., 154; 6 Mar., 656; 24 Apr., 1162; 17 July, 177; 31 July, 278; 18 Sept., 742
Coleman Instruments, Inc.
1958: 21 Nov., 1297
1959: 23 Jan., 225
Eldorado Electronics
1959: 10 Apr., 979
National Instrument Laboratories, Inc.
1959: 15 May, 1316

Perkin-Elmer Corp.
1958: 24 Oct., 946
Photovolt Corp.
1959: 25 Sept., 808

PHOTOMICROGRAPHIC EQUIPMENT

Aloe, A. S., Co., Aloe Scientific Div.
1958: 5 Dec., 1449
1959: 2 Jan., 45
American Optical Co.
1958: 24 Oct., 1052; 7 Nov., 1168
1959: 30 Jan., 288; 27 Feb., 584; 27 Mar., 856; 19 June, 1696
Bausch & Lomb Optical Co.
1958: 24 Oct., 968; 7 Nov., 1110; 21 Nov., 1250; 19 Dec., 1538
1959: 16 Jan., 122; 24 Apr., 1074
Brinkmann Instruments, Inc.
1959: 10 Apr., 973
Hacker, William J., & Co., Inc.
1959: 10 Apr., 979; 5 June, 1563
Leitz, E., Inc.
1958: 7 Nov., 1104
1959: 3 July, 2; 17 July, 183; 28 Aug., 519
Photovolt Corp.
1959: 25 Sept., 808
United Scientific Co.
1958: 24 Oct., 1051; 31 Oct., 1095; 5 Dec., 1365
1959: 16 Jan., 156; 30 Jan., 237; 8 May, 1294; 5 June, 1513; 17 July, 127; 14 Aug., 361; 18 Sept., 737
Zeiss, Carl, Inc.
1958: 24 Oct., 928
1959: 5 June, 1506

POLARIMETERS

Kern Co.
1959: 20 Feb., 490
Leitz, E., Inc.
1958: 24 Oct., 955
Photovolt Corp.
1958: 26 Dec., 1629
1959: 9 Jan., 103; 23 Jan., 219; 20 Feb., 513; 20 Mar., 793; 17 Apr., 1035; 29 May, 1503; 10 July, 111; 21 Aug., 458
Zeiss, Carl, Inc.
1958: 5 Dec., 1379
1959: 6 Mar., 596; 18 Sept., 665

POWER GENERATORS

Raytheon Manufacturing Co.
1958: 5 Dec., 1375; 26 Dec., 1595
1959: 30 Jan., 240; 6 Mar., 664a; 1 May, 1192; 15 May, 1376a; 29 May, 1498

POWER SUPPLIES

Donner Scientific Co.
1959: 20 Feb., 509; 3 Apr., 907; 5 June, 1560
Power Designs, Inc.
1958: 31 Oct., 1095
Research Specialties Co.
1959: 26 June, 1702; 7 Aug., 290
Technical Measurement Corp.
1958: 24 Oct., 966

PRINTING COUNTERS

Presin Co.
1958: 24 Oct., 1036
1959: 20 Feb., 523

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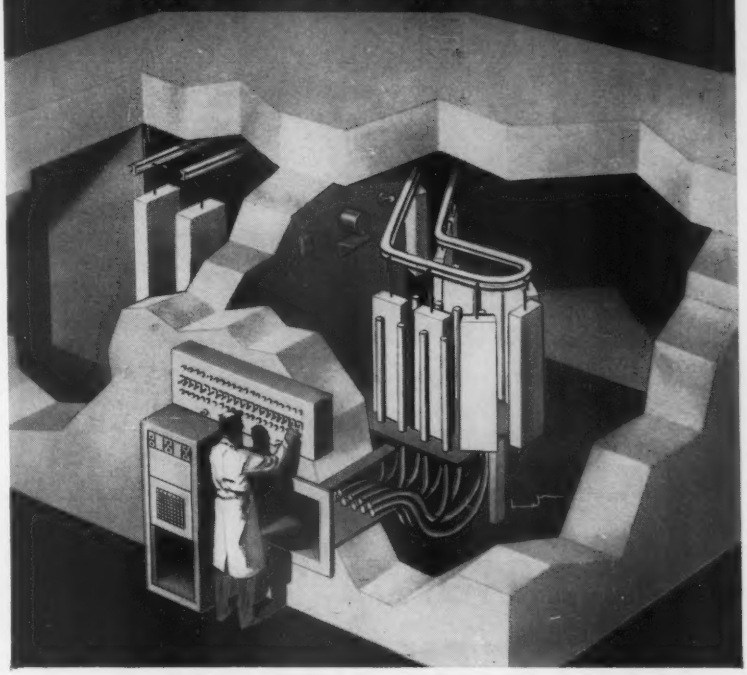

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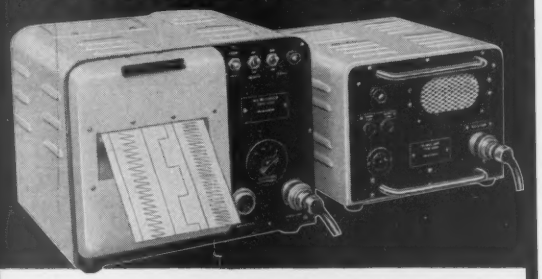

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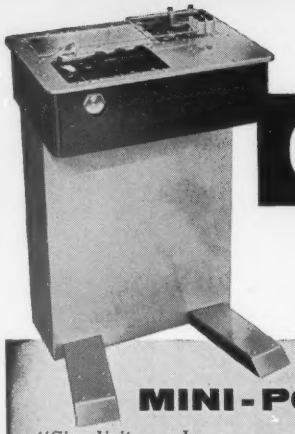

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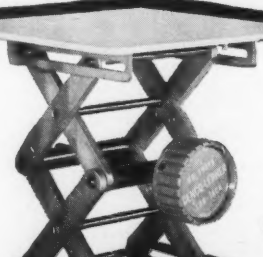

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PROJECTORS

Bausch & Lomb Optical Co.
1958: 5 Dec., 1392
1959: 27 Mar., 806; 10 Apr., 936; 8 May, 1248; 3 July, 8; 28 Aug., 476
Edmund Scientific Co.
1959: 1 May, 1188; 5 June, 1508; 7 Aug., 351; 11 Sept., 592
Hacker, William J., & Co., Inc.
1959: 6 Mar., 654
Leitz, E., Inc.
1958: 19 Dec., 1579
1959: 27 Feb., 533; 19 June, 1636; 25 Sept., 815
Phipps & Bird, Inc.
1958: 12 Dec., 1522
Zeiss, Carl, Inc.
1959: 24 Apr., 1066; 25 Sept., 757

PUMPS

Central Scientific Co.
1959: 16 Jan., 161; 17 Apr., 1035
Eastern Industries, Inc.
1959: 16 Jan., 155; 13 Feb., 396; 13 Mar., 728; 27 Mar., 850; 15 May, 1374; 29 May, 1497; 12 June, 1620; 17 July, 176; 31 July, 281; 14 Aug., 392; 11 Sept., 636; 25 Sept., 803
Harvard Apparatus Co., Inc.
1959: 16 Jan., 167; 6 Mar., 673
Kruger, Harold, Instruments
1959: 30 Jan., 283
New Brunswick Scientific Co.
1958: 24 Oct., 1016
1959: 20 Mar., 789
Phipps & Bird, Inc.
1958: 24 Oct., 1033; 5 Dec., 1457
1959: 20 Feb., 489; 19 June, 1685; 26 June, 1745; 24 July, 235; 31 July, 287; 7 Aug., 344
Sigmamotor, Inc.
1958: 7 Nov., 1162
1959: 20 Feb., 510

PUMPS, VACUUM

Consolidated Electrodynamics Corp., Rochester Div.
1958: 21 Nov., 1293; 19 Dec., 1585
Scientific Glass Apparatus Co., Inc.
1958: 24 Oct., 1026
Welch, W. M., Manufacturing Co.
1958: 24 Oct., 1029
1959: 2 Jan., 48

RADIATION COUNTERS

Amperex Electronics Corp.
1959: 6 Mar., 593
Anton Electronic Laboratories, Inc.
1958: 24 Oct., 950
1959: 9 Jan., 105; 6 Mar., 600
Baird-Atomic, Inc.
1958: 24 Oct., 1028; 14 Nov., 1216; 5 Dec., 1440
Cambridge Instrument Co., Inc.
1959: 8 May, 1299
Nuclear-Chicago Corp.
1958: 31 Oct., 1100; 14 Nov., 1232
1959: 18 Sept., 752
Nuclear Measurements Corp.
1958: 21 Nov., 1292
1959: 15 May, 1382; 18 Sept., 740
Packard Instrument Co., Inc.
1958: 24 Oct., 929; 31 Oct., 1054; 21 Nov., 1248; 19 Dec., 1536; 26 Dec., 1636
1959: 9 Jan., 68; 23 Jan., 178; 6 Feb., 302; 20 Feb., 442; 20 Mar., 750; 1 May, 1196; 29 May, 1456; 24 July, 194
Picker X-Ray Corp.
1959: 12 June, 1575; 18 Sept., 661
Science Materials Center
1959: 20 Feb., 413
Technical Measurement Corp.
1958: 14 Nov., 1180; 5 Dec., 1390
1959: 24 Apr., 1072; 8 May, 1246
Tracerlab, Inc.
1959: 10 Apr., 929

RATEMETERS

Anton Electronic Laboratories, Inc.
1958: 24 Oct., 950
1959: 9 Jan., 105; 6 Mar., 600
Nuclear Measurements Corp.
1959: 15 May, 1382; 18 Sept., 740
Nucleonic Corporation of America
1959: 3 July, 5
Picker X-Ray Corp.
1959: 12 June, 1575; 18 Sept., 661
Technical Measurement Corp.
1958: 24 Oct., 966

REAGENTS

Arapahoe Chemicals, Inc.
1958: 24 Oct., 1015
Baker, J. T., Chemical Co.
1959: 18 Sept., 678
Borden Chemical Co.
1959: 13 Mar., 731; 15 May, 1386

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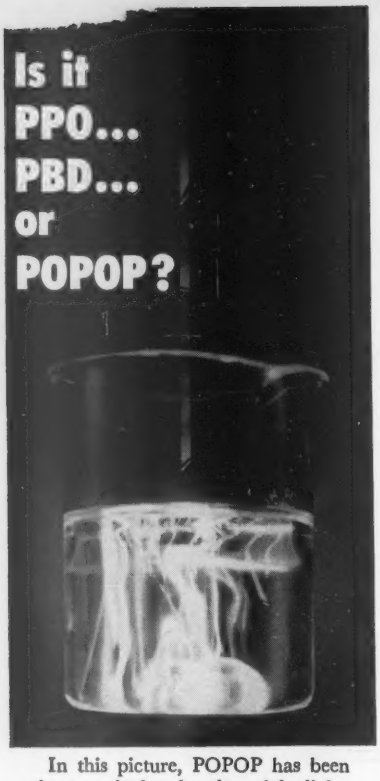

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Phenylbiphenylyloxadiazole-1, 3, 4
p-Bis [2- (5-phenyloxazolyl)]-benzene

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9, 10-Diphenylanthracene
p, p'-Diphenylstilbene
ALPHA-NPO — 2-(1-Naphthyl)-5-phenyloxazole
p-Quaterphenyl
p-Terphenyl
1, 1, 4, 4-Tetraphenylbutadiene

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CHEMICALS, INC.
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Difco Laboratories
1958: 26 Dec., 1631
1959: 20 Feb., 489; 13 Mar., 725; 28 Aug., 516; 25 Sept., 803
Klett Manufacturing Co.
1958: 19 Dec., 1586
1959: 16 Jan., 158; 13 Feb., 400; 13 Mar., 728; 10 Apr., 976; 8 May, 1298; 5 June, 1558; 3 July, 55; 31 July, 279; 28 Aug., 508; 25 Sept., 804
Matheson Co., Inc.
1959: 31 July, 276
Schwarz Laboratories
1959: 20 Mar., 791
Sigma Chemical Co.
1959: 2 Jan., 47; 27 Feb., 573

RECORDERS, GRAPHIC

American Instrument Co., Inc.
1958: 12 Dec., 1475
Fisher Scientific Co.
1959: 15 May, 1388; 12 June, 1621
Gilson Medical Electronics
1958: 7 Nov., 1159
1959: 20 Feb., 489
Houston Instrument Corp.
1959: 24 Apr., 1165
Photovolt Corp.
1958: 31 Oct., 1093; 5 Dec., 1449
1959: 6 Feb., 341; 6 Mar., 669; 10 Apr., 980; 15 May, 1385; 26 June, 1745; 31 July, 287; 7 Aug., 344
Sanborn Co., Medical Div.
1959: 18 Sept., 668
Sargent, E. H., & Co.
1958: 24 Oct., 934; 26 Dec., 1635
1959: 23 Jan., 173; 20 Feb., 429; 20 Mar., 748; 12 June, 1574; 10 July, 119; 7 Aug., 297
Standard Scientific Supply Corp.
1959: 6 Mar., 667
Stoelting, C. H., Co.
1958: 24 Oct., 1039; 19 Dec., 1583
1959: 26 June, 1751; 24 July, 234; 21 Aug., 458; 18 Sept., 734
Texas Instruments, Inc.
1958: 24 Oct., 940; 21 Nov., 1235
1959: 6 Feb., 293; 6 Mar., 598; 10 Apr., 927; 15 May, 1317
Welwyn International, Inc.
1959: 20 Feb., 432; 15 May, 1314

RECORDING EQUIPMENT, BIOPHYSICAL

Beckman Instruments, Inc., Spinco Div.
1958: 19 Dec., 1530
Gilson Medical Electronics
1959: 3 Apr., 911; 1 May, 1194; 5 June, 1558
Phipps & Bird, Inc.
1958: 14 Nov., 1231
Sanborn Co., Medical Div.
1958: 24 Oct., 964; 7 Nov., 1107; 28 Nov., 1312; 5 Dec., 1374
1959: 9 Jan., 65; 6 Mar., 607; 24 Apr., 1060; 1 May, 1186; 29 May, 1504; 26 June, 1704; 21 Aug., 412; 18 Sept., 668

REFRIGERATORS

Union Carbide Corp., Linde Co. Div.
1959: 6 Mar., 658; 19 June, 1687

ROTATORS

Fisher Scientific Co.
1959: 16 Jan., 159

SCALES

Mettler Instrument Corp.
1959: 6 Mar., 657; 15 May, 1373
Will Corp.
1959: 6 Mar., 668

SCALERS

Eldorado Electronics
1959: 6 Mar., 652
Nuclear Electronics Corp.
1959: 20 Feb., 520; 6 Mar., 674
Nucleonic Corporation of America
1959: 3 July, 5
Picker X-Ray Corp.
1959: 12 June, 1575; 18 Sept., 661
Technical Measurement Corp.
1959: 20 Feb., 440; 24 Apr., 1072; 5 June, 1516; 3 July, 6
Tracerlab, Inc.
1959: 10 Apr., 928

SHAKERS

American Instrument Co.
1959: 24 Apr., 1153
Laboratory Glass & Instruments Corp.
1958: 24 Oct., 942
1959: 20 Feb., 502
New Brunswick Scientific Co.
1958: 28 Nov., 1351
1959: 2 Jan., 47; 9 Jan., 106; 23 Jan., 217; 20 Feb., 497; 6 Mar., 670; 27 Mar., 849; 17 Apr., 1032; 15 May, 1373; 31 July, 279; 28 Aug., 509; 18 Sept., 739; 25 Sept., 808
Research Specialties Co.
1959: 9 Jan., 100; 21 Aug., 459

SKELETON, MODEL

Welch, W. M., Manufacturing Co.
1959: 6 Mar., 677; 3 July, 55

SPECTROFLUOROMETERS

Farrand Optical Co., Inc.
1958: 21 Nov., 1291; 5 Dec., 1461
1959: 23 Jan., 223; 3 Apr., 909; 3 July, 47; 18 Sept., 731

SPECTROGRAPHS

Bausch & Lomb Optical Co.
1959: 30 Jan., 242; 11 Sept., 598

SPECTROMETERS

Baird-Atomic, Inc.
1959: 20 Feb., 512; 12 June, 1582; 18 Sept., 664
Bendix Aviation Corp., Cincinnati Div.
1958: 5 Dec., 1465
1959: 6 Feb., 347; 3 Apr., 913; 5 June, 1561; 7 Aug., 343
Leitz, E., Inc.
1958: 24 Oct., 955
Packard Instrument Co., Inc.
1958: 24 Oct., 929; 21 Nov., 1248; 5 Dec., 1456; 26 Dec., 1636
1959: 9 Jan., 68; 23 Jan., 178; 6 Feb., 302; 3 Apr., 870; 17 Apr., 996; 1 May, 1196; 15 May, 1328; 29 May, 1456; 12 June, 1584; 26 June, 1710; 10 July, 70; 24 July, 194; 21 Aug., 420; 4 Sept., 534; 18 Sept., 650
Technical Measurement Corp.
1958: 24 Oct., 966; 5 Dec., 1390

1959: 24 Apr., 1072
Tracerlab, Inc.
1959: 10 Apr., 928
Varian Associates, Instrument Div.
1958: 28 Nov., 1359
1959: 20 Feb., 416; 17 July, 124

SPECTROPHOTOMETERS AND ACCESSORIES

American Electronic Laboratories, Inc.
1959: 25 Sept., 804
Applied Physics Corp.
1958: 24 Oct., 1035
1959: 6 Feb., 343; 24 Apr., 1175; 24 July, 233; 21 Aug., 463
Beckman Instruments, Inc., Scientific and Process Instruments Div.
1959: 13 Feb., 356, 357; 10 Apr., 932, 933; 12 June, 1573; 7 Aug., 295; 4 Sept., 526, 527; 18 Sept., 663
Brunswick-Balke-Collender Co., Aloe Scientific Div.
1959: 7 Aug., 341
Coleman Instruments, Inc.
1958: 7 Nov., 1153; 5 Dec., 1453
1959: 21 Aug., 467
Instrument Development Laboratories, Inc.
1959: 24 Apr., 1177
Perkin-Elmer Corp.
1958: 24 Oct., 946
1959: 6 Mar., 604; 10 Apr., 934; 18 Sept., 672
Scientific Glass Apparatus Co., Inc.
1958: 21 Nov., 1242
Will Corp.
1959: 20 Feb., 519; 24 Apr., 1180
Zeiss, Carl, Inc.
1959: 20 Feb., 426; 7 Aug., 300

SPECTROSCOPES

Bausch & Lomb Optical Co.
1958: 5 Dec., 1392
1959: 27 Mar., 806; 8 May, 1248
Leitz, E., Inc.
1958: 24 Oct., 955
Perkin-Elmer Corp., Instrument Div.
1959: 2 Jan., 4
Radio Corporation of America
1959: 21 Aug., 457
Science Materials Center
1959: 20 Feb., 413
Varian Associates, Instrument Div.
1959: 20 Feb., 416
Zeiss, Carl, Inc.
1958: 5 Dec., 1379

STERILIZERS

American Sterilizer Co.
1959: 20 Feb., 419; 6 Mar., 605; 12 June, 1577; 18 Sept., 653
Hospital Supply Co., Inc.
1959: 18 Sept., 740
Wilmot Castle Co.
1958: 24 Oct., 931
1959: 6 Mar., 589; 5 June, 1511

STILLS

American Sterilizer Co.
1958: 24 Oct., 937
1959: 24 Apr., 1046; 17 July, 125
Barnstead Still & Sterilizer Co., Inc.
1959: 2 Jan., 2; 20 Feb., 527
Smith, Arthur F., Co.
1958: 24 Oct., 958

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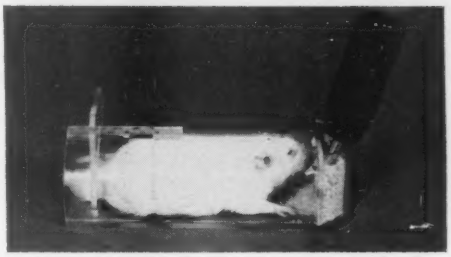
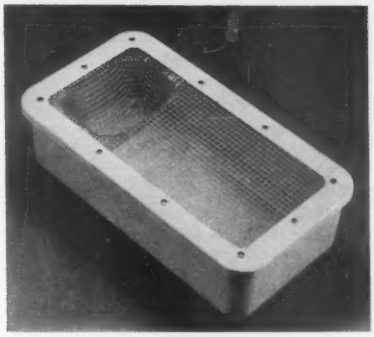


DEEP DRAWN WIRE MESH LIDS



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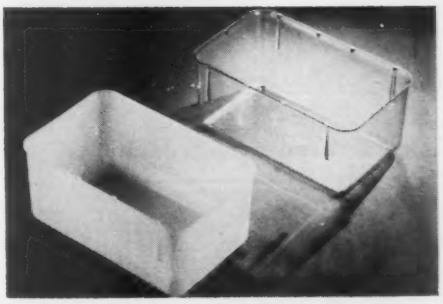

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MARYLAND PLASTICS, INC.
Federalsburg, Maryland

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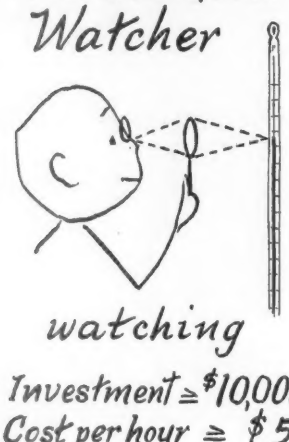
Watcher



watching

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Cost per hour ≅ $5

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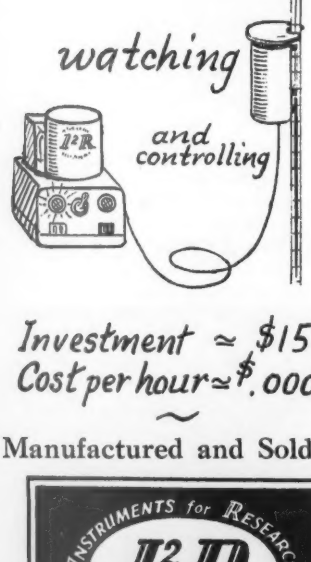
*TRADEMARK



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To Terminate Distillations
To Control Liquid Levels

STIMULATORS

Harvard Apparatus Co., Inc.
1958: 5 Dec., 1464

STIRRERS

Central Scientific Co.
1959: 23 Jan., 226; 10 Apr., 980; 26 June, 1745; 25 Sept., 803
Eastern Industries, Inc.
1959: 16 Jan., 155; 13 Feb., 396; 27 Mar., 850; 15 May, 1374; 12 June, 1620; 31 July, 281; 11 Sept., 636
Kontes Glass Co.
1959: 20 Mar., 746; 19 June, 1690; 18 Sept., 728
Palo Laboratory Supplies, Inc.
1959: 20 Feb., 522
Sticht, Herman H., Co., Inc.
1959: 18 Sept., 723
Tri-R Instruments
1958: 24 Oct., 1011
Welch, W. M., Manufacturing Co.
1958: 7 Nov., 1155

STOP CLOCKS

Dimco-Gray Co.
1958: 5 Dec., 1441
1959: 16 Jan., 161; 13 Feb., 402

STUDENT SCIENCE MATERIALS

Ace Glass, Inc.
1959: 15 May, 1376
Bausch & Lomb Optical Co.
1959: 8 May, 1248; 3 July, 8; 28 Aug., 476; 11 Sept., 598
Central Scientific Co.
1958: 12 Dec., 1520
1959: 6 Mar., 670; 15 May, 1368; 10 July, 114; 14 Aug., 393; 21 Aug., 458; 28 Aug., 514; 11 Sept., 635
Doerr Glass Co.
1959: 22 May, 1397
Edmund Scientific Co.
1958: 14 Nov., 1175; 28 Nov., 1309; 5 Dec., 1380
1959: 9 Jan., 111; 6 Feb., 299; 6 Mar., 679; 3 Apr., 862; 1 May, 1188; 5 June, 1508; 10 July, 62; 7 Aug., 351; 11 Sept., 592
Elgeet Optical Co., Inc.
1959: 18 Sept., 669
Gilson Medical Electronics
1958: 7 Nov., 1159
1959: 3 Apr., 911; 1 May, 1194
Graf-Apsco Co.
1958: 24 Oct., 1027; 7 Nov., 1163; 14 Nov., 1223; 5 Dec., 1463
1959: 16 Jan., 158; 20 Feb., 513; 6 Mar., 670; 24 Apr., 1177; 15 May, 1372; 18 Sept., 723
Lafayette Radio Co.
1959: 18 Sept., 736
Leitz, E., Inc.
1959: 24 Apr., 1044; 14 Aug., 358
Nuclear-Chicago Corp.
1959: 20 Feb., 528; 17 Apr., 1040; 15 May, 1392
Science Materials Center
1959: 20 Feb., 413
Standard Scientific Supply Corp.
1958: 5 Dec., 1448
United Scientific Co.
1958: 24 Oct., 1051; 7 Nov., 1152; 28 Nov., 1354; 5 Dec., 1354, 1365; 26 Dec., 1632
1959: 2 Jan., 461; 30 Jan., 237; 6 Feb., 342; 13 Mar., 732; 3 Apr., 864; 24 Apr., 1169; 1 May, 1232; 19 June, 1686; 14 Aug., 361; 18 Sept., 737
Varian Associates
1959: 14 Aug., 356; 18 Sept., 654
Welch, W. M., Manufacturing Co.
1959: 6 Mar., 677; 5 June, 1555; 7 Aug., 341
Will Corp., Bronwill Scientific Div.
1958: 19 Dec., 1581
1959: 14 Aug., 399

SYRINGES AND ACCESSORIES

Hamilton Co.
1958: 14 Nov., 1225
1959: 20 Feb., 505; 6 Mar., 654; 26 June, 1752; 14 Aug., 400
Phipps & Bird, Inc.
1959: 6 Mar., 651; 20 Mar., 793; 5 June, 1562; 12 June, 1623

TELESCOPES

Edmund Scientific Co.
1958: 14 Nov., 1175; 28 Nov., 1309; 5 Dec., 1380
1959: 9 Jan., 111; 6 Feb., 299; 6 Mar., 679; 3 Apr., 862; 1 May, 1188; 5 June, 1508; 10 July, 62; 7 Aug., 351; 11 Sept., 592
United Scientific Co.
1958: 7 Nov., 1152; 28 Nov., 1354; 26 Dec., 1632
1959: 2 Jan., 46; 6 Feb., 342; 13 Mar., 732; 3 Apr., 864; 1 May, 1232; 19 June, 1686

TEMPERATURE CONTROL EQUIPMENT

Brinkmann Instruments, Inc.
1958: 7 Nov., 1159
1959: 6 Mar., 663
Industrial Instruments Engineering Corp.
1958: 24 Oct., 1043
National Appliance Co.
1959: 23 Jan., 224; 5 June, 1559
New York Laboratory Supply Co., Inc.
1959: 18 Sept., 727
Precision Scientific Co.
1959: 12 June, 1578
Thomas, Arthur H., Co.
1958: 24 Oct., 926
Will Corp., Bronwill Scientific Div.
1959: 24 Apr., 1158; 28 Aug., 515; 18 Sept., 728
Yellow Springs Instrument Co.
1959: 14 Aug., 396

TENSIOMETERS

Central Scientific Co.
1959: 24 Apr., 1144; 29 May, 1500

THERMOMETERS

Ace Glass, Inc.
1958: 19 Dec., 1580
Advanced Instruments, Inc.
1958: 24 Oct., 1032
Brinkmann Instruments, Inc.
1959: 14 Aug., 359
Chemical & Pharmaceutical Industry Co., Inc.
1958: 24 Oct., 1048
Tri-R Instruments
1958: 24 Oct., 1011
1959: 10 Apr., 973

Yellow Springs Instrument Co.
1959: 30 Jan., 282

TISSUE GRINDERS

Kontes Glass Co.
1959: 27 Mar., 848; 8 May, 1295; 24 Apr., 1172; 22 May, 1440; 12 June, 1580; 25 Sept., 810

TITRATION EQUIPMENT

Ace Glass, Inc.
1959: 16 Jan., 116
American Hospital Supply Corp.
1959: 15 May, 1313
Beckman Instruments, Inc., Scientific and Process Instruments Division
1958: 14 Nov., 1176, 1177
Bellco Glass, Inc.
1959: 20 Feb., 510; 3 Apr., 915; 26 June, 1752
Brinkmann Instruments, Inc.
1959: 14 Aug., 359
California Laboratory Equipment Co.
1958: 24 Oct., 1029; 5 Dec., 1460
1959: 2 Jan., 49; 13 Feb., 400; 27 Mar., 846; 10 Apr., 979; 1 May, 1234; 29 May, 1494; 26 June, 1751; 24 July, 236; 21 Aug., 458; 18 Sept., 747
Central Scientific Co.
1958: 24 Oct., 1023; 28 Nov., 1349
1959: 6 Feb., 345; 13 Feb., 402; 22 May, 1443
Corning Glass Works
1959: 13 Mar., 727; 10 Apr., 924; 15 May, 1382; 5 June, 1515; 26 June, 1705
Doerr Glass Co.
1959: 20 Mar., 745; 17 Apr., 991; 18 Sept., 667
Fisher Scientific Co.
1958: 24 Oct., 949
1959: 17 July, 174
Greiner, Emil, Co.
1959: 9 Jan., 108; 23 Jan., 220; 20 Feb., 490; 13 Mar., 731; 27 Mar., 850; 24 Apr., 1146
Hamilton Co.
1959: 16 Jan., 155; 20 Feb., 505; 6 Mar., 654; 15 May, 1368; 18 Sept., 738
Instrumentation Associates
1959: 15 May, 1376b
Kimble Glass Co.
1959: 20 Feb., 417; 6 Mar., 603; 18 Sept., 659
Kontes Glass Co.
1959: 26 June, 1756; 14 Aug., 395
Laboratory Glass & Instruments Corp.
1958: 24 Oct., 943; 14 Nov., 1223
1959: 20 Feb., 503; 6 Mar., 672
Micro-Ware, Inc.
1958: 5 Dec., 1462
National Instrument Laboratories, Inc.
1959: 18 Sept., 743
Palo Laboratory Supplies, Inc.
1959: 23 Jan., 226; 6 Mar., 661; 10 Apr., 976; 18 Sept., 735
Phipps & Bird, Inc.
1959: 6 Mar., 651; 20 Mar., 793; 5 June, 1562; 12 June, 1623
Photovolt Corp.
1959: 30 Jan., 278
Research Specialties Co.
1958: 5 Dec., 1464
Sargent, E. H., & Co.
1959: 15 May, 1323; 4 Sept., 522
Scientific Industries, Inc.
1958: 24 Oct., 1024
1959: 6 Mar., 652; 12 June, 1624

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1959: 26 June, 1707
Thomas, Arthur H., Co.
1959: 12 June, 1632; 31 July, 242
Welwyn International, Inc.
1959: 20 Feb., 432; 12 June, 1572; 18 Sept., 670

TRANSDUCERS, PRESSURE

Sanborn Co., Medical Div.
1959: 6 Feb., 351; 21 Aug., 412

TRANSFORMERS

Superior Electric Co.
1959: 18 Sept., 744

TUBES

Falcon Plastics
1959: 17 Apr., 994; 15 May, 1391

VACUUM EQUIPMENT

Ace Glass, Inc.
1958: 21 Nov., 1290
Blickman, S., Inc.
1958: 19 Dec., 1584
1959: 23 Jan., 222; 20 Feb., 514; 20 Mar., 790
Consolidated Electrodynamics Corp.
1958: 21 Nov., 1293; 19 Dec., 1585
Corning Glass Works
1958: 24 Oct., 965; 19 Dec., 1532
Hughes Aircraft Co.
1959: 11 Sept., 635
Kontes Glass Co.
1959: 20 Mar., 746; 18 Sept., 728
Matheson Co., Inc.
1959: 9 Jan., 104
National Research Corp., NRC Equipment Corp.
1958: 24 Oct., 1014; 21 Nov., 1286; 19 Dec., 1586
Scientific Glass Apparatus Co., Inc.
1958: 24 Oct., 1026
1959: 24 Apr., 1145
Welch, W. M., Manufacturing Co.
1958: 24 Oct., 1029
1959: 2 Jan., 48

VACUUM DRY BOXES

Blickman, S., Inc.
1958: 24 Oct., 1013; 21 Nov., 1246; 19 Dec., 1584
1959: 23 Jan., 222; 20 Feb., 514; 20 Mar., 790

VALVES

Kontes Glass Co.
1959: 6 Mar., 608; 3 Apr., 866; 10 July, 66; 7 Aug., 298; 11 Sept., 637
Phipps & Bird, Inc.
1959: 8 May, 1299; 15 May, 1379

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Gilson Medical Electronics
1958: 5 Dec., 1372
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Will Corp., Bronwill Scientific Div.
1959: 27 Feb., 579; 17 Apr., 1033; 21 Aug., 465

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1959: 27 Feb., 574, 575; 24 Apr., 1142, 1143; 28 Aug., 508, 509
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1959: 20 Mar., 786

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Ainsworth, Wm., & Sons, Inc.
1958: 21 Nov., 1295

X-RAY EQUIPMENT

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1958: 24 Oct., 932
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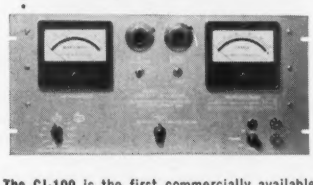

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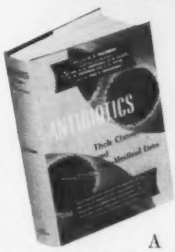

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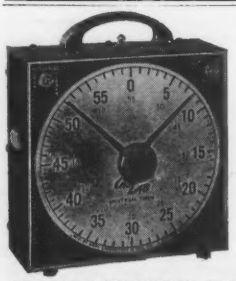

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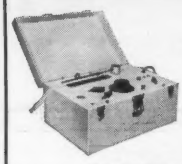

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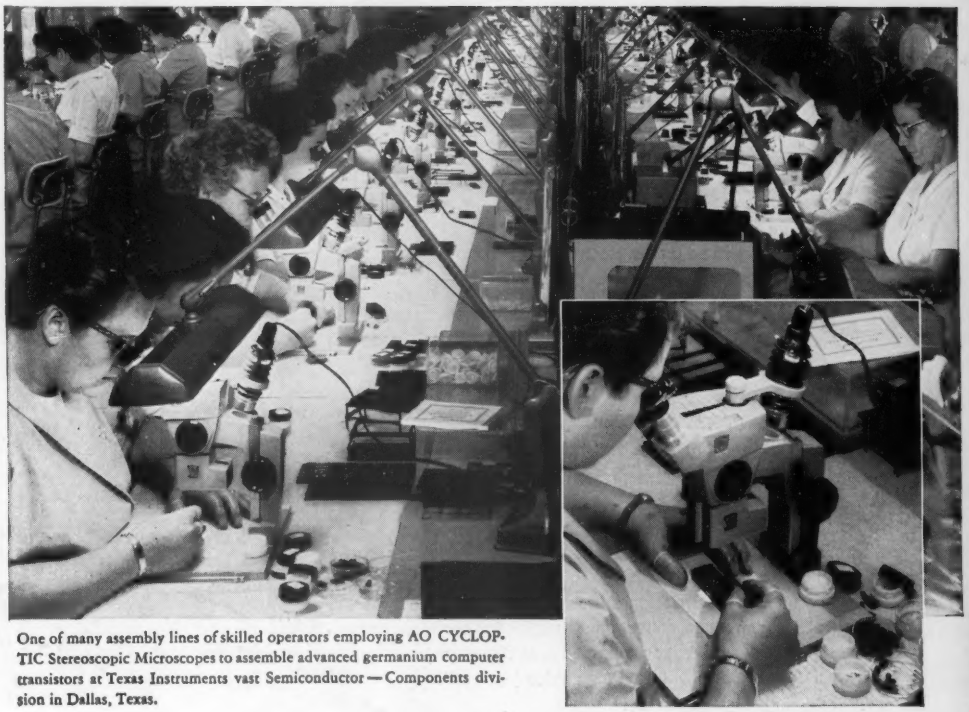

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